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Zinc/Zinc Oxide Preliminary Source Assessment

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Zinc/Zinc Oxide Preliminary Source Assessment

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A preliminary source assessment of industries with zinc and/or zinc oxide emissions is presented. Brief descriptions of these industries and associated air pollution control equipment are presented. Zinc/zinc oxide emission data were primarily obtained from the National Air Toxics Information Clearinghouse. The Appendix presents zinc/zinc oxide emission data that were used in the Human Exposure Model. This Model is used by EPA's Pollutant Assessment Branch to evaluate health risks from various pollutants.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park NC 27711
April 1987

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INTRODUCTION

The purpose of this project was to identify the major sources of zinc and/or zinc oxide emissions. This was accomplished through a literature search, through contacts with State air pollution agencies, and from information gathered as part of the cadmium Phase I project (ESED 80/42). Additional information was retrieved from the National Air Toxics Information Clearinghouse (NATICH) database in the form of permit information and from the National Environmental Data System (NEDS) database. The information from NATICH was limited to permit data from the States of Texas, Minnesota, Illinois, and New York. The majority of the information came from New York. A significant amount of permit information was obtained from New York by retrieving and prioritizing the permit numbers available in NATICH. Eighty permits were identified and requested that represented 50 of the 70 industries where zinc or zinc oxide are manufactured, used, or emitted. The other 20 industries were eliminated from consideration because the permit information showed either trace emissions or emissions of less than or equal to 0.001 pounds of zinc/zinc oxide per hour.

This report contains six chapters. The first four chapters present four industries for which a large amount of information was readily available. These industries, primary zinc, secondary zinc, brass and bronze, and iron and steel, were studied separately because the literature showed them to be potentially large sources of zinc emissions. The other two chapters contain information on miscellaneous uses of zinc and zinc oxide.

For the iron and steel chapter, four model plants were presented because they had been developed during an earlier study of cadmium emissions. Insufficient information was readily available to develop model plants for other industry categories.

For the primary zinc/zinc oxide chapter, inputs for the Human Exposure Model (HEM) were available for specific emission sources at each plant from the cadmuim Phase I project. In addition, zinc/zinc oxide specific information including HEM data was available from the States of New York, Kentucky, and Illinois. The HEM input data are presented in the Appendix to this report.

1. THE PRIMARY ZINC/ZINC OXIDE INDUSTRY

1.1 BACKGROUND INFORMATION

There are currently four primary zinc smelters in operation in the U.S. Of these, one is an electrothermic smelter while the other three are electrolytic smelters. All four plants process zinc sulfide ore concentrates that may range from 50 to 63 percent zinc.[1] The electrothermic smelter, due to the nature of the production process, also processes zinc secondary materials such as zinc skimmings, drosses, scrap metal, and oxidics. There is one primary zinc oxide smelter in operation. The following sections briefly discuss the three production processes.

1.1.1 Electrolytic Zinc Production

A process flow diagram for a typical electrolytic zinc smelter is shown in Figure 1-1.

1.1.1.1 Roasting. The first step in the production of zinc metal from ore concentrates at both electrolytic and electrothermic zinc smelters is the roasting operation. Zinc roasting consists of heating the ore concentrates to 650° to 1000°C (1200° to 1800°F) in an oxidizing environment. The roast is carried out below the melting temperature of the charge and has three primary functions: (1) elimination of sulfur as SO_2, (2) conversion of zinc sulfide to impure zinc oxide, and (3) removal of volatile impurities from the ore concentrate. The degree of sulfur elimination accomplished in a zinc roaster varies from about 93 to 97 percent.[2]

The fluid bed roaster is the newest roasting system for zinc sulfide concentrates and is currently the only type in use. The offgas stream from a fluid bed zinc roaster typically has an SO_2 concentration of 10 to 13 percent, and up to 85 percent of the roaster product (calcine) is

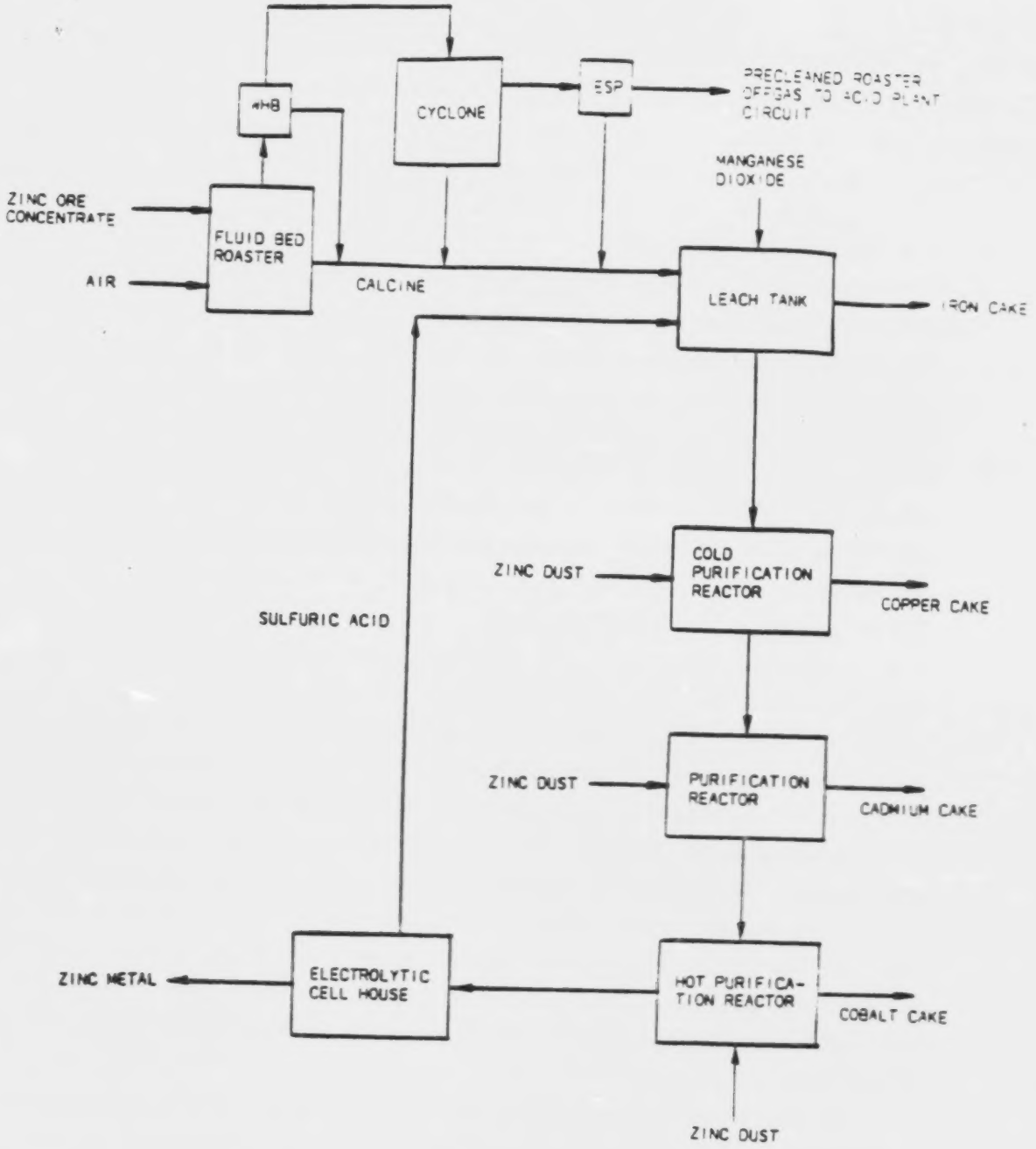

Figure 1-1. Typical process flow diagram for an electrolytic zinc smelter.[8]

carried out with the offgas. Waste heat boilers, cyclones, and electrostatic precipitators are used in series to capture the entrained portion of the calcine. The cleaned gas is then ducted to a sulfuric acid plant. At electrolytic zinc plants, the collected materials are normally combined with the remaining portion of the calcine and stored prior to leaching and purification.[2]

1.1.1.2 Leaching and Purification. The roaster calcine is first leached in a dilute sulfuric acid solution to dissolve the impure zinc oxide. Manganese dioxide (MnO_2) is generally added to the leach tank to cause the precipitation of an iron cake that contains iron and significant amounts of arsenic, antimony, and silicic acid. The leachate is then sent to a series of cold and hot purification tanks where cadmium, copper, and cobalt are removed from solution. The precipitation reactions that occur are induced by the addition of zinc dust, which reduces Cd^{+2}, Cu^{+2}, and Co^{+2} to their respective metallic forms.[2] All three electrolytic smelters recover the precipitated cadmium and sell it as cadmium metal or cadmium oxide.

1.1.1.3 Electrodeposition. The purified zinc sulfate solution from the purification system is passed to the cell room where an electric potential applied to the solution causes zinc metal to form on the surface of aluminum cathodes. Hydrogen gas is also evolved causing the formation of sulfuric acid, which is recycled to the leach tank.[3] The zinc metal sheets are subsequently stripped from the cathodes and stored prior to melting and casting.

1.1.1.4 Melting and Casting. The zinc metal sheets are charged to an electric induction furnace and melted down. Ammonium chloride typically is added to the zinc sheets as a flux. The molten zinc is then pumped to a holding furnace where pneumatic jets direct the molten zinc into molds. Any impurities that form on the top of the freshly poured zinc are skimmed off. Water is sprayed on top of the molds to aid in cooling. At some plants, the area in which this cooling takes place is enclosed. The zinc slabs are subsequently removed from the molds, stacked, and stored for sale.

1.1.2 Electrothermic Zinc Production[4]

The process flow diagram for the electrothermic zinc smelter is shown in Figure 1-2.

1.1.2.1 Roasting and Sintering. The zinc sulfide ore concentrates are dried in a rotary dryer prior to roasting. Emissions from the dryer are controlled by a venturi scrubber. The dried ore concentrates are then roasted in a fluid bed roaster. Emissions from the roaster are controlled in series by a cyclone, waste heat boiler, electrostatic precipitator, and a wet scrubber. The cleaned gas is then ducted to a double-adsorption sulfuric acid plant.

Roaster calcine, sand, coke breeze, electrothermic furnace residue, blue powder from the electrothermic furnaces, scrubbers, and return sinter fines are mixed together and pelletized. The pelletized material is then roasted in downdraft sinter machines at an operating temperature from 1200° to 1300°C (2200° to 2400°F). The sinter machine product is subsequently crushed and screened. Sinter fines from screening are recycled to the sinter machines. Emissions from the sinter machines and from the crushing and sizing operation are controlled by separate baghouses.

1.1.2.2 Electrothermic Furnace Operations. The advantage of the electrothermic process over the electrolytic process is that a significant portion of the feed may be comprised of secondary material. Sinter, coke, and secondary materials are heated and mixed in a rotary preheater and then charged to an electrothermic furnace. Emissions from the electrothermic furnace preheaters are controlled by a baghouse. Electricity is passed through eight pairs of graphite electrodes located at the top and bottom of the furnace to generate the heat required for smelting. Furnace vapors, including zinc vapor, are drawn through a water-cooled condenser and bubbled through a molten zinc bath. The gases vented from the condenser are scrubbed with water from high-velocity impingers. The clean gas, which contains about 80 percent carbon monoxide, is recovered and used as fuel. Any uncondensed zinc is recovered by settling the water slurry in ponds. This zinc, which is called blue powder, is recycled to the roaster. Furnace residue is discharged on a rotary table at the base

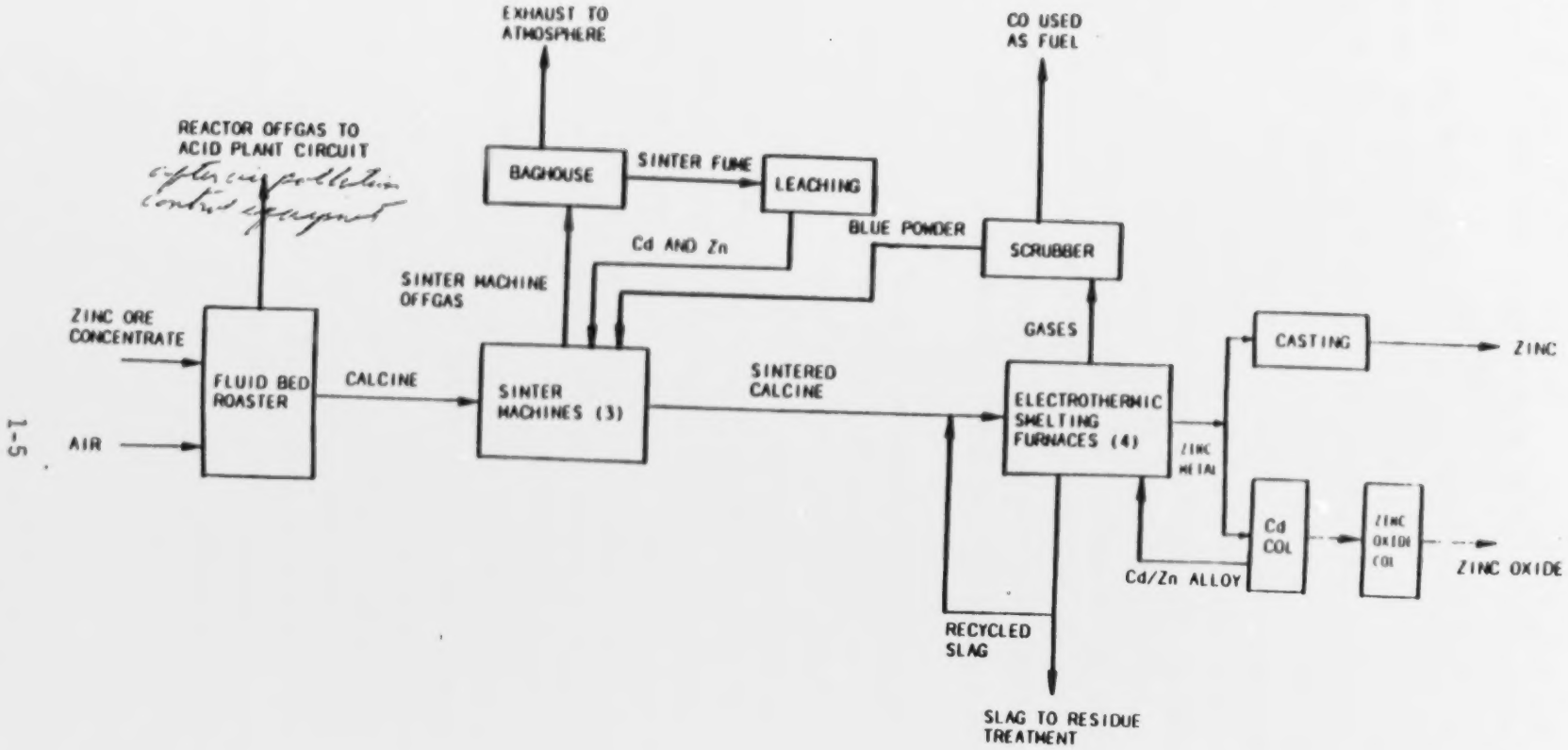

Figure 1-2. Process flow diagram for the electrothermic zinc smelter, St. Joe Resources Company, Monaca, Pennsylvania.[9]

of the furnace. It is then treated to recover coke and unsmelted zinc and to segregate slag and ferrosilicon by-products.

1.1.2.3 Zinc Casting. Molten zinc from the electrothermic furnace condenser is passed to a holding furnace. The zinc may then be cast into 25-kilogram (kg) (55 lb) slabs, 227-kg (500-lb) blocks, or 1,090-kg (2,400-lb) jumbo blocks. The casting process is fully automated. Molten zinc from the holding furnace is tapped into molds which travel on a conveyor. Dross that forms on the surface of the molten zinc after tapping is skimmed off and stored for later use as furnace feed material. As the conveyor proceeds, water is poured on top of the molten zinc to aid in cooling the slabs. The slabs then pass into a hooding and ventilation system where more water is sprayed onto the slabs; the steam produced is drawn off to the atmosphere. The cooled slabs of zinc are then mechanically removed from the molds, stacked, and stored for shipment.

1.1.2.4 Zinc Refining. Further refining of the zinc metal is accomplished using two refining columns known as the cadmium column and the lead column. Molten zinc from the electrothermic furnace is transferred to the cadmium column in large ladles. The molten zinc is fed at a constant rate to the column and flows inside carbide trays. The column is operated at a temperature high enough to drive off metals, including cadmium, with a lower boiling point than zinc. Vapor from the column is condensed in a condenser. The resulting cadmium/zinc alloy contains approximately 3 percent cadmium by weight. This alloy is recycled to the electrothermic furnaces.

The partially purified zinc collected at the bottom of the cadmium column is processed through another column known as the lead column. Here, the zinc is further purified by driving off zinc vapor and leaving behind higher boiling metals such as lead and iron. The zinc vapor is either condensed to produce high purity zinc metal slabs or oxidized to produce high purity zinc oxide. The zinc oxide powder is captured in product collection baghouses. Offgases from the refining columns are vented to two other baghouses.

1.1.3 The American Zinc Oxide Process

In the American zinc oxide manufacturing process, zinc ore concentrates are used as the zinc feed material. Another process used to manufacture zinc oxide, known as the French process, uses high purity zinc metal as a feed material and, is, therefore, a secondary zinc process. Secondary zinc processes are described in Chapter 2 of this report.

The process flow diagram for the American zinc oxide process at The New Jersey Zinc Company in Palmerton, Pennsylvania, is shown in Figure 1-3. The current design capacity of the American process at this plant is 15,000 megagrams per year (16,500 tons per year).[5] This plant processes a low-sulfur zinc ore known as Sterling crude ore that has a cadmium content of about 0.004 percent by weight.[5] Ore and coal are fed to the Waelz kilns where metals are volatilized and oxidized. The Waelz oxide product is cooled and collected in a bagroom. The oxide is then sintered in a downdraft sinter machine to reduce impurities, such as lead and chloride. The last step in the process is the final oxidation and purification. The sinter is mixed with coal and fed to a moving grate furnace. The oxide is volatilized, reduced to metallic zinc, and then oxidized again. The purified zinc oxide is then collected in a baghouse.[6]

1.2 EMISSIONS

Table 1-1 lists the primary zinc plant locations and production capacities.

Tables 1-2 and 1-3 list the zinc emission sources for electrolytic and electrothermic plants, respectively. For the most part, zinc emissions to the atmosphere are controlled. The exceptions are zinc ore concentrate storage and handling and zinc metal tapping and casting. Each of the four plants has a building for storage of zinc ore concentrates. However, the outdoor storage of this material is a potential fugitive source of zinc sulfide emissions at three plants. Zinc tapping and casting is uncontrolled at each of the four plants although ventilation to the atmosphere is in place at three of the plants.

Table 1-4 lists the zinc oxide emission sources for the American process at The New Jersey Zinc Company. Zinc oxide emissions to the atmosphere are controlled by baghouses at each source.

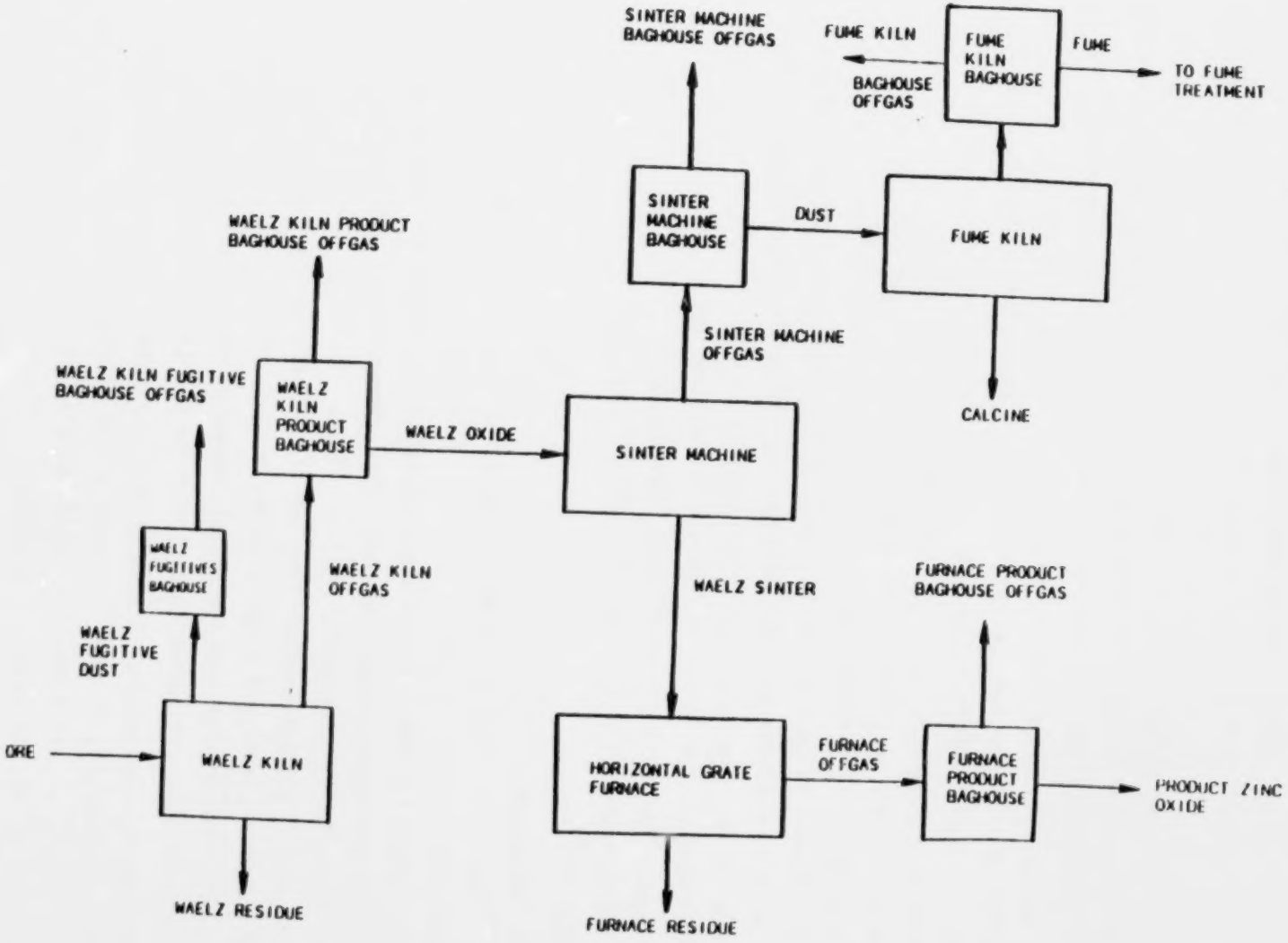

Figure 1-3. Process flow diagram for the American Zinc Oxide Process, New Jersey Zinc Company, Palmerton, Pennsylvania.[10]

TABLE 1-1. PRIMARY ZINC PLANT LOCATIONS AND CAPACITIES[7]

Plant name	Location	Capacity, Mg/yr (tons/yr)
AMAX Zinc Company, Inc.	East St. Louis, Ill.	72,000 (80,000)
Jersey Miniere Zinc	Clarksville, Tenn.	82,000 (90,000)
St. Joe Resources/National Zinc Division	Bartlesville, Okla.	51,000 (56,000)
St. Joe Resources[a]	Monaca, Pa.	90,000[b] (100,000)[b]

[a]St. Joe, Monaca, is the only electrothermic zinc smelter. The others are electrolytic smelters.
[b]As zinc equivalent (includes slab zinc, zinc dust, and zinc oxide).

TABLE 1-2. ZINC EMISSION SOURCES AT ELECTROLYTIC ZINC SMELTERS

Emission source	Emission control
Ore storage and handling	Baghouses, buildings, or none
Roasters	Acid plant and associated gas cleaning equipment
Zinc melting	Baghouse
Zinc tapping/casting	None; ventilation to the atmosphere in place at three plants
Haul roads	Road sweepers and water sprays

TABLE 1-3. ZINC EMISSION SOURCES AT THE ELECTROTHERMIC ZINC SMELTER

Emission source	Emission control
Ore storage and handling	Storage building and dust suppressant on open storage piles
Ore dryer	Scrubber
Roaster	Acid plant and associated gas cleaning equipment
Sinter machines	Baghouse
Sinter sizing/crushing	Baghouse
Electrothermic furnace preheaters	Baghouse
Electrothermic furnaces	Condenser and scrubber in a closed loop system
Zinc holding furnace	Baghouse
Zinc tapping/casting	None; ventilation to atmosphere
Zinc metal powder process	Closed loop system; no emissions
Refining columns	Baghouses
Zinc oxide process	Baghouses
Haul roads	Road sweeper with water sprays

TABLE 1-4. AMERICAN PROCESS ZINC OXIDE SOURCES AT NEW JERSEY ZINC

Emission source	Emission control
Ore storage and handling	None
Waelz kiln fugitives	Baghouse
Waelz kiln process	Baghouse
Sinter machine	Baghouse
Fume kiln	Baghouse
Horizontal grate furnace	Baghouse

1.3 REFERENCES FOR CHAPTER 1

1. Section 114 questionnaire responses from AMAX Zinc, Jersey Miniere Zinc, St. Joe Resources (National Zinc Division), and St. Joe Resources, Monaca. April through June, 1986.

2. Radian Corp. Background Information Document for Cadmium Emission Sources. EPA No. 68-02-3818, Assignment No. 23. May 1985. p. 43.

3. Reference 2, p. 44.

4. Turner, M. B., MRI, Trip Report to St. Joe Resources, Monoca, Pennsylvania. August 6, 1986.

5. Section 114 questionnaire response from The New Jersey Zinc Company, Palmerton, Pennsylvania. May 16, 1986.

6. Reference 2, p. 61-63.

7. Reference 2, p. 40.

8. Reference 2, p. 42.

9. Reference 2, p. 45.

10. Reference 2, p. 62.

2. THE SECONDARY ZINC INDUSTRY

2.1 BACKGROUND INFORMATION

The secondary zinc industry is defined here as those facilities that refine scrap zinc materials into other zinc products such as slab zinc, zinc dust, zinc oxide, and zinc-based alloys. The distinction between primary and secondary zinc is based on the source of the zinc feed material; primary zinc is derived from zinc-bearing ores while secondary zinc is produced from zinc scrap materials. The manner in which zinc scrap materials are processed is dependent entirely on their type and quality. Low grade scrap typically requires some form of refining before production of end-products while high grade scrap may require relatively little pretreatment. The following sections describe the various processes associated with the secondary zinc industry including scrap preparation, distillation and remelting. Table 2-1 lists the secondary slab zinc producers, locations, and total production capacity (individual capacities were not available.) Table 2-2 lists the secondary zinc oxide producers, locations, and capacities.

2.1.1 Scrap Preparation[1]

The zinc scrap feed material may be grouped into four broad categories: galvanizers' scrap (mainly drosses, skimmings, ashes), new die-cast scrap (reject castings), mixed die-cast scrap (auto shredders' scrap, auto parts, appliance parts), and general zinc scrap (clippings, engravers plates). Figure 2-1 shows a typical process flow diagram.

Typically, the new die-cast scrap and general zinc scrap require little or no preparation prior to processing. These materials may be melted down and blended to achieve the proper market specifications.

Galvanizers' scrap (primarily drosses, skimmings, sal skimmings, and ashes) are largely shipped from galvanizing operations in drums or solid

TABLE 2-1. SECONDARY SLAB ZINC PLANT CAPACITY IN THE U.S., BY COMPANY*

Company/Plant location	Capacity, metric tons 1983	1984
Arco Alloys Corp., Detroit, Mich.		
W. J. Bullock, Inc., Fairfield, Ala.		
T. L. Diamond and Company, Inc., Spelter, W. Va.		
Gulf Reduction Corp., Houston, Tex.		
Hugo Neu-Proler Company, Terminal Island, Calif.		
Huron Valley Steel Corp., Belleville, Mich.	95,000	95,000
Interamerican Zinc Company, Adrian, Mich.		
The New Jersey Zinc Company, Inc., Palmerton, Pa.		
Pacific Smelting Company, Torrance, Calif.		
Pacific Smelting Company, Memphis, Tenn.		
Prolerized Schiabo Neu Company, Jersey City, N.J.		

TABLE 2-2. SECONDARY ZINC OXIDE PRODUCERS[5]

Plant name/location	Capacity, metric tons
American Chemet Corp.	8,000
ASARCO, Inc., Hillsboro, Ill.	13,000
T. L. Diamond and Company, Inc., Hillsboro, Ill.	20,000
St. Joe Resources Company, Monaca, Pa.	45,000
Huron Valley Steel Corp., Trenton, Mich.	16,000
Inland Zinc, Spokane, Wash.	2,000
Midwest Zinc Corp., Chicago, Ill.	10,000
The New Jersey Zinc Company, Palmerton, Pa.	41,000
Pacific Smelting Company, Millington, Tenn.; Torrance, Calif.	20,000
Philipp Brothers Chemis., Inc., The Prince Mfg. Company, subsidiary, Bowmanstown, Pa.	5,000
Superior Zinc Corp., Bristol, Pa.	3,000

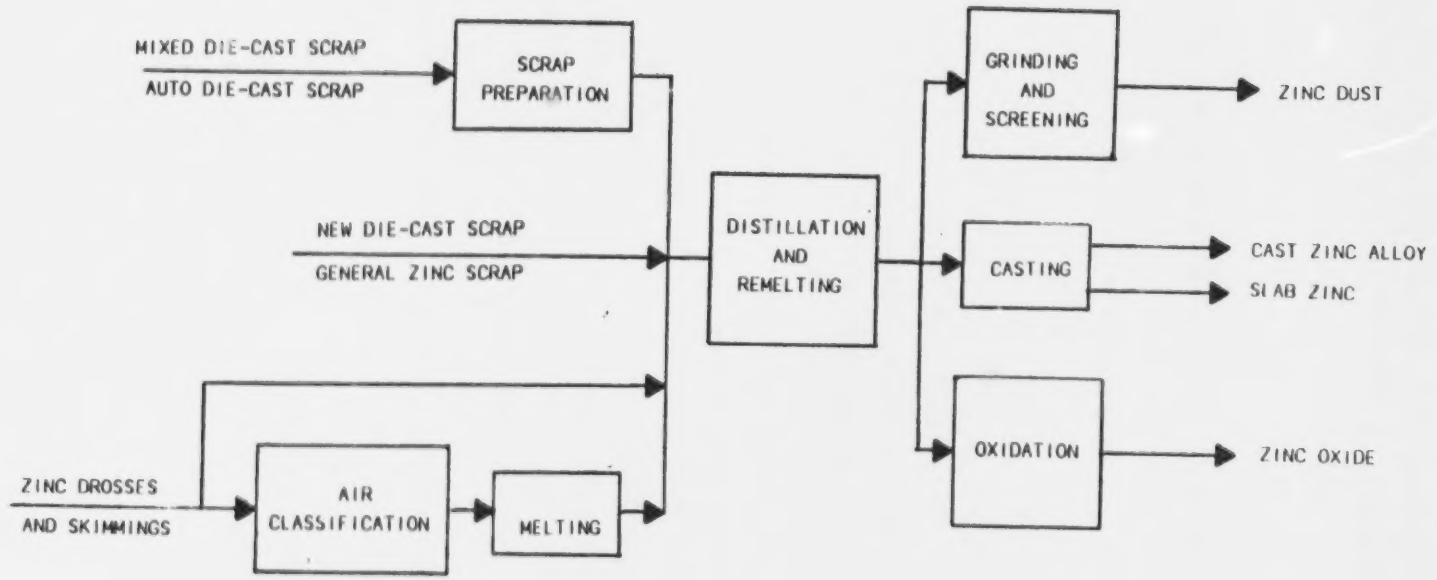

Figure 2-1. Flow diagram for secondary zinc processing.[8]

blocks to the scrap-consuming plant. In many plants, they are charged to the distillation furnace either directly or after first being melted in a separate operation. Some plants dry mill and air classify the zinc skimmings to separate the metallic zinc from zinc oxide. In other plants, skimmings are crushed and then treated in the following manner. The crushed skimmings are washed with water to separate nonmetals as a slurry and allow zinc-containing metal particles to settle out; the slurry is then treated with Na_2CO_3 to convert chlorides (mainly $ZnCl_2$) to NaCl, forming insoluble $Zn(OH)_2$. Most of the NaCl is separated from the insoluble residues by filtration and settling; the residue is dried and calcined in a kiln to convert $Zn(OH)_2$ to ZnO by driving off H_2O and vaporizing any remaining $ZnCl_2$. The calcined product is mostly ZnO and is suitable for smelting. The kiln fume is collected and recycled.

Mixed die-cast scrap contains a large amount of ferrous and nonferrous material. It is a low grade zinc scrap material and requires pretreatment in a sweating process to produce a higher purity zinc product suitable for further processing in a distillation operation. Sweating involves melting the zinc scrap to separate both unmeltable attachments and nonmetallic residues. Agitation and the addition of a fluxing agent help promote metal separation. The unmeltable attachments settle to the bottom of the furnace and are removed, and the nonmetallic residues are skimmed from the molten surface. The resulting zinc metal may then be cast into blocks for further processing; fed directly to a distillation furnace; or it may be sampled, analyzed, and alloyed with other metals to obtain the desired specification. Several types of furnaces are available for sweating operations including reverberatory furnaces, rotary furnaces, and kettle furnaces.

2.1.2 Distillation and Remelting[2]

New die-cast scrap, general scrap, and purified zinc from sweating furnaces are processed further either by pot melting or by distillation.

Pot melting involves remelting and heating the scrap material to enhance separation of impurities that are skimmed from the metal surface. The purified zinc metal may then be cast into zinc slabs or alloyed and cast into zinc alloy ingots.

Distillation involves boiling the zinc scrap material and either condensing the vapor rapidly to produce powdered zinc, condensing the vapor more slowly to produce liquid zinc, or contacting the vapor with an air stream to produce zinc oxide. The zinc oxide stream is captured in a product collection baghouse.

2.2 EMISSIONS

Tables 2-3 and 2-4 list the zinc emission sources and effluents for both secondary sweating processes and secondary distillation processes. Typically, these systems are controlled by baghouses. Some plants augment baghouse control on sweating processes with afterburners to control any organic emissions resulting from the processing of scrap contaminated with oil, paint, etc.[3]

TABLE 2-3. EMISSION POINTS AND EFFLUENTS OF SECONDARY ZINC-SWEAT PROCESSES[6]

Process (defined by type of furnace used)	Emitting process equipment unit	Emission point of process equipment unit	Constituents of effluents from emission points
Kettle furnace	Melt kettle	Top of melt kettle (or surface of metallurgical process bath, formed from charge).	A. Emissions from process charge. 1. Products of combustion or thermal decomposition of organic materials in charge. 2. Emissions derived from metals, fluxes, and residues in metallurgical process bath, including metal oxides resulting from presence of air contacting metal.
Reverberatory furnace	Combustion chamber, containing melting hearth. (May also be referred to as "sweating chamber".)	Furnace flue (exhausting combustion chamber).	A. 1.-2. Emissions from process charge (same items as listed above.) B. Air induced or infiltrated into furnace, then into flue (would be in excess of air consumed in combustion). C. Products of combustion of fuel (usually natural gas).
		Openings for charging and fluxing; and removal of unmeltables and skimmings.	A. 1.-2.; B.; and C. Same items as listed above for furnace flue. These effluents are formed from (1) gases escaping from the furnace; (2) emissions from the molten metal and skimmings being withdrawn from furnace with unmeltables; and (3) ambient air.
Rotary furnace flue	Rotating, cylindrical melt unit. (May also be referred to as "sweating chamber" or "combustion chamber.")	Furnace flue (high end of melting cylinder).	A. 1.-2.; B.; and C. Same as listed above for reverberatory furnace, except emissions derived from flux are not normally contained in rotary furnace effluent.

TABLE 2-4. EMISSION SOURCES AND EFFLUENTS OF SECONDARY ZINC-DISTILLATION PROCESSES[7]

Process (defined by type of furnace used)	Emitting process equipment unit	Emission point of process equipment unit	Constituents of effluents from emission points
Retort furnace system	Distillation retort	Opening of distillation unit. (Emissions occur during removal of distillation residues. This opening may be refered to as "charging holes." It is used for applying charge to retort and removing residues.)	A. Emissions from distillation residues. 1. ZnO (makes up most of emitted particulates). 2. Oxides of other metals (mainly Al_2O_3) - small amounts. B. Ambient air.
	Condenser	Pressure relief valve. (Used to retain positive pressure and exclude air from condenser.)	A. Emissions from vapors distilled from retort charge. Partly oxidized by residual air in retort and condenser system. 1. ZnO particulate. 2. Metallic zinc dust (particulate). 3. Chloride particulates, derived from flux. (Very small amounts may occur when dross is charged to retort.) B. N_2 from residual air in retort and condenser.
	Condenser	"Speise" hole. (Used instead of pressure relief for same purpose. Zn vapor escaping from condenser through speise hole is oxidized in air, producing ZnO particulates.)	A. Emissions from vapors distilled from retort charge and oxidized. 1. ZnO particulate, nearly pure. (The charge to retort is of molten metal which would not produce chloride emissions) B. N_2 from residual air in retort and condenser. C. Ambient air.
Muffle furnace system	Melt unit (reverberatory furnace)	Flue of melt-unit combustion chamber.	A. Emissions from melt-unit charge. 1. Products of combustion or thermal decomposition of organic materials in charge. 2. Emissions derived from metals and residues (usually no flux) in metallurgical-process bath, including metal oxides resulting from presence of air. B. Air induced or infiltrated into melt unit, then into flue. (Would be in excess of air consumed in combustion.) C. Products of combustion of fuel (usually natural gas), burned in melt unit and vaporizing unit.

(continued)

TABLE 2-4. (continued)

Process (defined by type of furnace used)	Emitting process equipment unit	Emission point of process equipment unit	Constituents of effluents from emission points
Muffle furnace system (continued)		Openings in melt unit for charging scrap material and removing unmeltables skimmings.	A. 1.; 2.; and C. Same items as listed above for furnace flue. These effluents are formed from (1) gases escaping from the melt unit; and (2) emissions from the molten metal and skimmings being withdrawn from melt unit with unmeltables; and (3) ambient air.
	Vaporizing unit (muffle furnace)	Tap hole of vaporizing unit. (Emissions occur during removal of distillation residue.)	A. Emissions from distillation residues. 1. ZnO particulate, nearly pure. B. Ambient air.

2.3 REFERENCES FOR CHAPTER 2

1. McElroy, A. D. et al. Source Category Survey: Secondary Zinc Smelting and Refining Industry. U. S. Environmental Protection Agency. EPA-450/3-80-012, May 1980. pp. 28-29.

2. Reference 1. pp. 32, 34, 36.

3. Reference 1. p. 49.

4. Jolly, James H. Zinc Chapter in Minerals Yearbook. U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 1984. p. 16.

5. SRI International 1985 Directory of Chemical Producers. p. 966.

6. Reference 1. p. 31.

7. Reference 1. p. 38.

8. Reference 1. p. 27.

3. SECONDARY BRASS AND BRONZE PLANTS

3.1 BACKGROUND INFORMATION

Classically, when copper is alloyed with zinc the product is termed brass, and when copper is alloyed with tin the product is termed bronze. Normally the zinc content of brass ranges from 5 to 37 percent, while the zinc content of bronze is generally not more than 5 percent. Other copper alloys are identified by the alloying metals such as aluminum bronze and silicon bronze. Table 3-1 lists the 12 categories of brass and bronze that have been designated by the Brass and Bronze Ingot Institute. The table also shows subcategories of the alloys along with the chemical specifications and characteristics of each.[1]

Secondary brass and bronze companies are usually small, individually owned firms consisting of one plant. A few are subsidiary operations of large mining companies or of conglomerates. As of 1983, 37 secondary brass and bronze plants in 13 States were in operation; these plants are listed in Table 3-2.[1]

The brass and bronze manufacturing industry basically consists of three operations: raw materials collection and preparation, metal melting and ingot production, and metal product fabrication.[2]

The following sections discuss raw materials preparation and melting as they relate to zinc emissions in the brass and bronze ingot production process.

3.1.1 Raw Materials Preparation[3]

The raw materials used in the secondary brass and bronze ingot industry consist mainly of brass and bronze scrap, with virgin metals used only to adjust the composition of the product. Some scrap may require cleaning before furnace charging to remove contaminants such as oil, grease, paint, insulation, and chemicals.

TABLE 3-1. BRASS AND BRONZE ALLOYS, CHEMICAL SPECIFICATIONS, AND PRODUCT CHARACTERISTICS[17]

Alloy No.	Classificiation	Cu, %	Sn, %	Pb, %	Zn, %	Fe, %	Al, %	Ni, %	Si, %	Mn, %	Characteristics
1A	Tin bronze	88.0	10.0		2.0						Corrosion resistant; good for casting.
1B	Tin bronze	88.0	8.0		4.0						
2A	Leaded tin bronze	88.0	6.0	1.5	4.0						
2B	Leaded tin bronze	87.0	8.0	1.0	4.0						
2C	Leaded tin bronze	87.0	10.0	1.0	2.0						
3A	High-lead tin bronze	80.0	10.0	10.0							Malleable; readily machined.
3B	High-lead tin bronze	83.0	7.0	7.0	3.0						
3C	High-lead tin bronze	85.0	5.0	9.0	1.0						
3D	High-lead tin bronze	78.0	7.0	15.0							
3E	High-lead tin bronze	71.0	5.0	24.0							
4A	Leaded red brass	85.0	5.0	5.0	5.0						Inexpensive, corrosion-resistant, good for casting and machining (useful for water systems).
4B	Leaded red brass	83.0	4.0	6.0	7.0						
5A	Leaded semi-red brass	81.0	3.0	7.0	9.0						
5B	Leaded semi-red brass	76.0	2.5	6.5	15.0						
6A	Leaded yellow brass	72.0	1.0	3.0	24.0						Moderately strong; easily machines and polishes.
6B	Leaded yellow brass	67.0	1.0	3.0	29.0						
6C	Leaded yellow brass	61.0	1.0	1.0	37.0						
7A	Manganese bronze	59.0	1.0	1.0	37.0	1.0	0.6			0.5	High tensile strength; corrosion resistant to sea water.
8A	Hi-strength manganese bronze	57.5			39.0	1.0	1.0			1.5	
8B	Hi-strength manganese bronze	64.0			24.0	3.0	5.0			3.5	
8C	Hi-strength manganese bronze	64.0			24.0	3.0	5.0			3.5	
9A	Aluminum bronze	88.0				3.0	9.0				High tensile strength and hardness; resistant to fatigue and high temperature.
9B	Aluminum bronze	89.0				1.0	10.0				
9C	Aluminum bronze	85.0				4.0	11.0	2.0		0.5	
9D	Aluminum bronze	81.0				4.0	11.0	4.0		3.0	
10A	Leaded nickel brass	57.0	2.0	9.0	20.0			12.0			Excellent mechanical properties; tarnish and corrosion-resistant.
10B	Leaded nickel brass	60.0	3.0	5.0	16.0			16.0			
11A	Leaded nickel bronze	64.0	4.0	4.0	8.0			20.0			
11B	Leaded nickel bronze	66.5	5.0	1.5	2.0			25.0			
12A	Silicon bronze	88.0			5.0	1.5			4.0	1.5	Good for casting (leaves a clean casting surface).
12b	Silicon brass	82.0			14.0				4.0		

TABLE 3-2. PRODUCERS OF BRASS AND BRONZE, FEBRUARY 1983[18]

Company	Location
American Brass, Inc.	Headland, Ala.
ASARCO, Inc.	San Francisco, Calif.
The G.A. Avril Company	Cincinnati, Ohio
Bay State Refining Company, Inc.	Chicopee, Mass.
Belmont Smelting & Refining Works, Inc.	Brooklyn, N.Y.
Bohn Aluminum and Brass	Adrian, Mich.
Bridgeport Brass	Indianapolis, Ind.
Brush Wellman, Inc.	Cleveland, Ohio
W. J. Bullock, Inc.	Fairfield, Ala.
Harry Butter & Company, Inc.	Dorchester, Mass.
Cabot Berylco Ind. Inc.	Reading, Pa.
Cerro Metals	Newark, Calif.
Cerro Metals	Bellefonte, Pa.
Chase Brass and Copper	Montpelier, Ohio
Chase Brass and Copper	Solon, Ohio
Chicago Extruding Metals	Chicago, Ill.
Colonial Metals Company	Columbia, Pa.
Federal Metal Company	Bedford, Ohio
N. Kamenske & Company, Inc.	Nashua, N.H.
Kearny Smelting & Refining Corp.	Kearny, N.J.
H. Kramer & Company	El Segundo, Calif.
H. Kramer & Company	Chicago, Ill.
R. Lavin & Sons, Inc.	Chicago, Ill.
Liberman S Gittlen Metal Company	Grand Rapids, Mich.
Milward Alloy, Inc.	Lockport, N.Y.
Mishawaka Brass Manufacturing, Inc.	Mishawak, Ind.
National Metals, Inc.	Leeds, Ala.
New England Smelting Works, Inc.	West Springfield, Mass.
North American Smelting Company	Wilmington, Del.
North Chicago Refining & Smelting, Inc.	Anniston, Ala.
River Smelting & Refining Company	Cleveland, Ohio
Roessing Bronze Company	Mars, Pa.
S-G Metals, Ind., Inc.	Kansas City, Kans.
I. Schumann & Company	Bedford, Ohio
Sipi Metals Corp.	Chicago, Ill.
Specialloy, Inc.	Chicago, Ill.

Material preparation processes may be mechanical, hydrometallurgical, or pyrometallurgical. The first two processes are not considered in this description since they are not sources of particulate emissions. Mechanical processing is not a source of particulate emissions because the scrap is typically in large pieces with any smaller pieces being coated in oil or grease. Hydrometallurgical processing takes place in a water medium.[4]

Pretreatment by pyrometallurgical "methods" may include any of the following: sweating, burning, drying, blasting furnaces, and cupola. These methods all involve the use of heat in varying amounts for preliminary processing of brass and bronze scrap. A brief description of each method is given below.

Sweating furnaces may be used to remove valuable low-melting point metals, such as lead, solder, and babbit metal. This is done by heating the scrap in a furnace, which causes the low-melting components to be separated from the desirable metals. Carefully controlled burning usually is performed for removal of insulation, wrappings, and other specialized materials from wire or cable scrap. Drying furnaces are used to vaporize substances such as cutting fluids from machine shop scrap.

The terms "blast furnace" and "cupola" are often used interchangeably. However, the cupola is used to melt down metals or reduce metal oxides, while the blast furnace is used for reduction of metal oxides or smelting virgin ores. Both furnaces also are used to recover metal from skimmings and slags. In both blast and cupola furnaces, coke is used as both fuel and reducing agent. The resulting product (black copper or cupola melt) is impure and must be refined to produce brass and bronze ingots. The blast furnace and cupola operate on a continuous feed basis with charge material, coke, and fluxes introduced at the top. Finished metal is drawn from the bottom, generally on an intermittent basis. Slag is usually tapped on a continuous basis through a separate spout at a level immediately above the metal pouring height.

3.1.2 Melting[5]

Brass and bronze are usually heated in large natural-, gas-, or oil-fired reverberatory furnaces or electric arc or induction furnaces. Indirect-fired furnaces are sometimes used for specific foundry applications.

Any furnace in which the burner flames and/or hot gases come in direct contact with the charged material is considered to be a reverberatory furnace. Reverberatory furnaces may also be the rotating, rocking, or tilting type. All reverberatory furnaces operate in the batch mode. The charge material and fluxes may be introduced before firing or may be added periodically throughout the heat. The fuel burned is either oil or natural gas. Stationary furnaces usually are larger (100- to 200-Mg [110- to 220-ton] capacity) than the other types of reverberatory furnaces, which have capacities ranging from 1 to 45 Mg (1 to 50 tons).

Electric furnaces are mainly used for special purpose alloys. Major advantages of the electric furnace over fuel-fired furnaces are better furnace atmosphere control and high-temperature operation. Temperatures as high as 3300°C (6000°F) are possible for special processes. In all cases, charging and pouring are generally done through the top of the furnace.

Indirect-fired furnaces (crucible or pot furnaces) usually are significantly smaller than reverberatory furnaces and are similar in function to electric furnaces. Indirect-fired furnaces are used either in small foundries or for special purpose alloys in small batches. Crucibles may be the tilting, pit, or stationary type and include the small, low-temperature pot furnaces. Charge materials are introduced through the top of the furnace along with inert fluxes. Finished alloys are removed from the furnaces through the top, either by tilting and pouring or by the use of ladles. Generally, crucible furnaces are used to heat metals up to 1300°C (2400°F). Pot furnaces are used only for temperatures up to about 760°C (1400°F).

3.2 EMISSIONS

Baghouses are considered to be the best demonstrated technology for the control of particulate emissions in the secondary brass and bronze industry.[6]

3.2.1 Emissions From Materials Preparation

Pyrometallurgical processing (sweating, wire burning, drying, and using blast or cupola furnaces) releases the greatest amount of particulate matter of any of the secondary brass and bronze production

procedures. It has been estimated that approximately 72 percent of secondary brass and bronze emissions are from pyrometallurgical processes.[7]

Sweating processes are carried out at fairly low temperatures and, as a result, have low metal fume losses associated with them.[7] Wire burning is the largest single source of particulate matter in the secondary brass and bronze industry with an uncontrolled particulate emission factor of 6.88 kilograms per megagram of scrap processed (13.75 pounds per ton).[8] Many companies are eliminating the use of these processes by being more selective in the scrap they accept.

A rotary dryer is often used to vaporize excess cutting fluids from machine shop chips or borings. The potential process fugitive particulate matter emission factor for rotary dryers is the same as that for wire burning; however, the nature of the combustion process determines the degree to which these emissions are oxidized.[9]

Preparation of materials in blast furnaces and cupolas results in emissions that are similar to emissions from the smelting/melting furnaces. However, since blast furnaces and cupolas are generally used to concentrate low-grade scrap, slag, and skimmings, emissions from these sources have a higher percentage of nonmetallic particles than do emissions from smelting/melting furnaces. Reports of uncontrolled emissions from three blast furnaces of unspecified size range from 16 to 100 kg/h (36 to 220 lb/h).[10]

3.2.2 Emissions From Smelting

Air pollutants emitted from secondary brass and bronze smelting furnaces consist of products of combustion, dusts, and metallic fumes. The particulate matter comprising the dust and fume load varies according to the fuel, alloy composition, type of furnace, melting temperature, with the presence of impurities in the scrap feed, and other operating factors. In addition to fly ash, carbon, and mechanically produced dust, furnace emissions generally contain fumes resulting from oxidation and condensation of the more volatile elements, including zinc, lead, and others. Most of the particulate emissions are metal oxides, predominately zinc oxides (45 to 77 percent zinc by weight) and lead oxides (1 to 13 percent lead by weight). Zinc fumes are 0.03 to 0.5 μm in diameter.[11]

Uncontrolled reverberatory furnaces can emit as much as 80 lbs of particulate matter per ton of ingot produced. The level of emissions from blast furnaces (cupolas) is approximately equal to that from reverbatory furnaces; the level of emissions from electric furnaces is typically far lower. The composition of emissions from blast furnaces is similar to that from reverberatory furnaces. Emissions from electric furnaces are also expected to be similar because the process and raw materials are identical.[12]

Direct-fired furnaces of the reverberatory and rotary type produce larger quantities of metallic fumes, such as zinc and lead oxide, than do the indirect-fired furnaces, which are usually small in size.[4] This is due to the introduction of the hot burner flames and gases directly on the charge, resulting in vaporization of large quantities of the lower boiling point metals.[10]

The potential for particulate emissions, both primary (through the stack) and secondary (fugitive), varies with the stage of the production cycle which may be divided into five parts: charging, melting, refining, alloying, and pouring. In general, the ratio of metallic fumes to other particulate substances in the emissions will increase as the production cycle proceeds.[4] This is due to the constant elimination of impurities in the charge which account for the bulk of the nonmetallic particulates.[13]

3.2.2.1 Charging. Charging emissions are dependent on the condition of the scrap, location of the charging doors, percentage of volatile alloy constituents, and upon whether the entire charge is made at the beginning of the heat or at intervals during the melt. Even if scrap has been pretreated to remove contaminants, particulate and unburned hydrocarbon emissions can still occur during charging. Overhead charging doors, used in stationary reverberatory furnaces (which are being replaced by rotary reverberatory furnaces) permit losses of hot gases, fly ash, and fume into the plant when charges are loaded at intervals during the heat. End and side charging doors in rotary-type furnaces significantly reduce the escape of furnace gases during charging.[14]

3.2.2.2 Melting. The furnace is closed for the meltdown process. Increased zinc oxide emissions can result from improper combustion, overheating of the charge, and heating the charge too fast. The use of nonuniform scrap can also increase emissions.[14]

3.2.2.3 Refining. Refining, a chemical process of purification, is that cycle of smelting in which impurities and other constituents of the charge, present in excess of specifications, are reduced or removed. Refining methods vary depending on the type of furnace, composition of the scrap, and the desired alloy, but the basic approach is the same for all. The chemicals used in refining, commonly termed fluxes, may be gaseous, liquid, or solid. Compressed air is the most extensively used flux. Zinc is partially oxidized during this process.[15]

3.2.2.4 Alloying. Alloy modifications are made during the heating process by the addition of virgin metals or scrap. This can cause an increase in fume emissions. The formation of fumes increases as the percentage of volatile constituents increases. Due to its very low boiling point, zinc is the most serious problem, with the rate of zinc loss being approximately proportional to the zinc percentage in the alloy.[16]

3.2.2.5 Pouring. Physical methods of pouring the molten alloy into molds vary; however, in all cases, metal oxide fumes are emitted when the hot molten metal is poured through the air. For a given percentage of zinc, an increase in temperature of 56°C (100°F) increases the rate of loss of zinc about three times. Other dust may be produced, depending upon the type of linings or coverings associated with the mold as it is filled with molten metal.[16]

3.3 REFERENCES FOR CHAPTER 3

1. Review of New Source Performance Standards for Secondary Brass and Bronze Plants. EPA-450/3-84-009. May 1984. p. 2-2.

2. Reference 1, p. 2-8.

3. Reference 1, pp. 2-8 - 2-11.

4. A Review of Standards of Performance for New Stationary Sources--Secondary Brass and Bronze Plants. EPA-450/3-79-011. June 1979. pp. 4-20 - 4-21.

5. Reference 1, pp. 2-11 - 2-14.

6. Reference 1, p. 4-5.

7. Reference 4, p. 4-32.

8. U. S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, Supplement No. 9. Third Edition (including supplements 1-7). Office of Air and Waste Management. Research Triangle Park, N.C. AP-42. July 1979. p. 7.9-7.

9. Reference 1, pp. 4-1 - 4-2.

10. Reference 4, p. 4-33.

11. Reference 4, p. 4-2.

12. Technical Report No. 11--Secondary Brass and Bronze Ingot Production Plants. p. 45.

13. Reference 4, p. 4-36.

14. Reference 1, p. 4-3.

15. Reference 1, pp. 4-3 - 4-4.

16. Reference 1, p. 4-4.

17. Reference 1, p. 2-3.

18. Reference 1, pp. 2-5 - 2-6.

4. THE IRON AND STEEL INDUSTRY

4.1 BACKGROUND INFORMATION

The iron and steel industry is defined as all producers of coke, iron, steel, specialty steel, and cast iron. Iron and steel producing plants are located in 39 States. Most of the plants, however, are located in the areas east of the Mississippi River and north of the Ohio River.[1] Table 4-1 lists the iron and steel producers in the U.S. This list was compiled from the 1985 Directory of Iron and Steel Plants.

Steel mills are important sources of zinc emissions because zinc in the iron ore is volatilized in the blast furnace and zinc in the scrap iron is volatilized in the open-hearth, basic oxygen, and electric arc furnaces.[2] Zinc is also emitted during iron and steel galvanizing. The following sections briefly describe the iron and steel production process and the sources of zinc emissions in this process.

4.1.1 General Process Description

Coke is used in steel mills and iron foundries to provide the heat necessary to produce molten iron. Coke is either hauled to the steel mill or made in a coke facility at the steel mill. Coke, limestone, and iron ore are combined in the blast furnace. The blast furnace produces molten iron. Molten iron is removed from the blast furnace and transferred to the steel-making furnaces. Scrap metal is commonly mixed with the molten iron in the steel furnaces. The whole mix is then made into steel by heat-refining the metal and adding alloying materials and fluxes. The molten steel is cast into various shapes, then sent through a finishing process.[3] Figure 4-1 illustrates the process flows for an integrated steel mill representing the iron and steel industry.

4.1.1.1 Blast Furnace. Iron is produced in the blast furnace from a charge of iron ore, coke, and limestone. The iron ore descends down the

furnace and is reduced and melted by the countercurrent flow of hot gases produced by the partial combustion of coke. Hot metal is removed from the bottom of the blast furnace and transferred to steel-making operations.[3]

4.1.1.2 Steel Furnaces. There are three types of steel-making furnaces in use today. These are the open hearth furnace (OHF), the basic oxygen furnace (BOF), and the electric arc furnace (EAF). Most of the nation's steel is made in BOF's and EAF's. The OHF takes the longest time (between 8 and 12 hours) to produce a batch of finished steel. The BOF uses about 70 percent hot metal and 30 percent scrap and requires a cycle of less than an hour to produce a batch of finished steel. In the BOF, a water-cooled lance is used to supply pure oxygen to a mixture of hot metal, steel scrap, and flux materials. The oxygen reacts exothermically with the carbon in the metal, producing the heat required for melting. In the EAF, carbon electrodes supply the heat necessary for melting the metal. Flux is added after the metal is molten. Molten metal is tapped from the steel furnace and poured into ingot molds. The EAF can melt up to 100 percent scrap metal.[3]

4.1.1.3 Galvanizing. Galvanizing is a process by which iron and steel are protected against corrosion. The hot dip process is the most important galvanizing method used for coating clean iron and steel surfaces with a thin layer of zinc. Zinc readily combines with iron to form an alloy coating consisting of several layers, each increasing in zinc content from the steel to the surface. The basic steps in the galvanizing process are: (a) preparation of the metal surface by degreasing, rinsing, pickling, and rerinsing; (b) prefluxing by immersion of the metal in a tank of preflux; (c) galvanizing by immersion in a tank of molten zinc for 3 to 20 seconds at a temperature of 450°C (840°F); and (d) finishing by shaking or centrifuging, water quenching, deburring, and inspecting.[2] For continuous operations, the average galvanizing kettle capacity is about 18 megagrams (Mg) (20 tons) of zinc per Mg (ton) of material galvanized per hour.

4.2 EMISSIONS

Model facilities were developed to estimate the hourly and annual zinc emissions expected from individual sources and to provide information

that is useful for future dispersion analyses. These model facilities are a blast furnace shop, a BOF shop, an EAF shop, and an OHF shop at an integrated steel mill. Figures 4-2 through 4-5 present the model facility parameters.[3] These model facilities were developed by GCA Corporation during a 1981 study of cadmium emissions from iron and steel plants. Zinc emission factors developed during other studies were used to calculate zinc emissions from the GCA model facilities.[2,6]

4.2.1 Blast Furnaces

Various types of control equipment are presently used to control particulate emissions from blast furnaces. Dry cyclones, wet scrubbers, and electrostatic precipitators (ESP's) are common. Essentially all of the zinc is volatilized into the blast furnace gas. The estimated zinc content of the particulate is 0.5 percent.[2]

Blast furnace gas is almost universally treated to produce a high purity, low heating value fuel. The only time even a trace amount of zinc would be emitted would be from process upsets such as blast furnace slips that actuate the relief valve, which discharges uncontrolled particulates to the atmosphere. These upsets are infrequent; consequently, there are only trace zinc emissions from blast furnaces.[3]

4.2.2 Steel Furnaces

The small size of the particulate matter emitted from OHF's necessitates the use of high-efficiency collection equipment such as venturi scrubbers and ESP's. Baghouses also have been installed for particulate emission control but they require that the gases be precooled. The average emission factor (controlled) for all OHF's is 10.2 lb of particulate per ton of steel produced, with an average zinc content of 12.5 percent.[2]

Venturi scrubbers and ESP's are commonly used to control particulate emissions from BOF's. The emissions are usually routed through either an open or closed hood. The controlled emission factor for BOF's is 14 lb of particulate per ton of steel produced with an average zinc content of 2.24 percent.[2]

Fabric filters are the most commonly used devices for cleaning EAF gases, although venturi scrubbers and ESP's are also used. The use of a baghouse on an EAF necessitates precooling of gases to protect the bags.

The average controlled emission factor for EAF's is 2.5 lb particulate matter per ton of steel produced, with a zinc content of 29.6 percent.[2]

4.2.3 Galvanizing

During hot dip galvanizing operations, most of the atmospheric pollutants are discharged when fresh flux is added or when the flux cover is disturbed as an article is immersed in the zinc bath. Ammonium chloride is the principle pollutant; however, there are significant quantities of zinc, zinc oxide, and zinc chloride in the fumes as shown in Table 4-2. Based on these emission data, zinc emissions to the atmosphere are estimated to be 0.0018 Mg/Mg of zinc processed (4 lb/ton).[2]

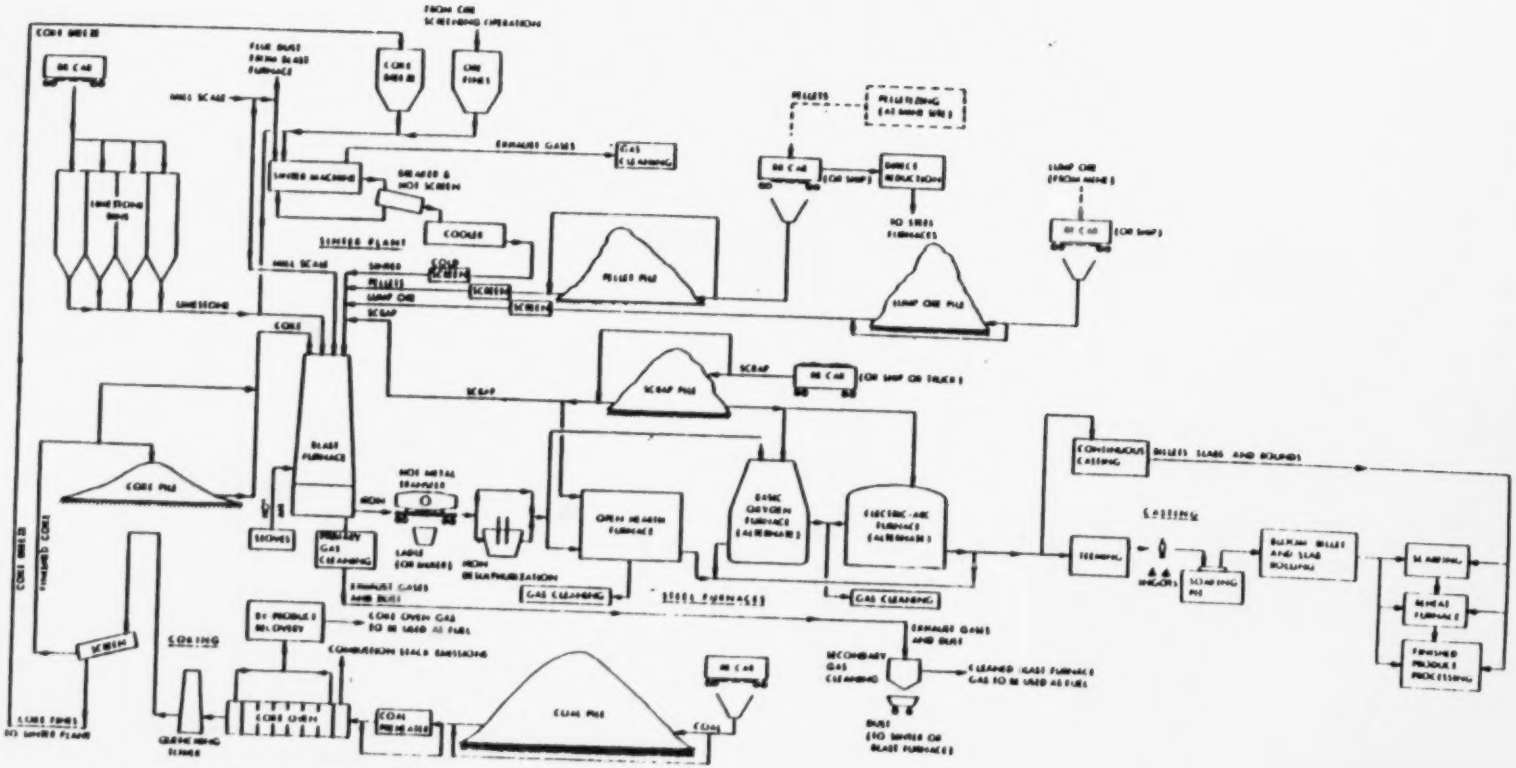

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Figure 4-1. General flow diagram for the iron and steel industry.[4]

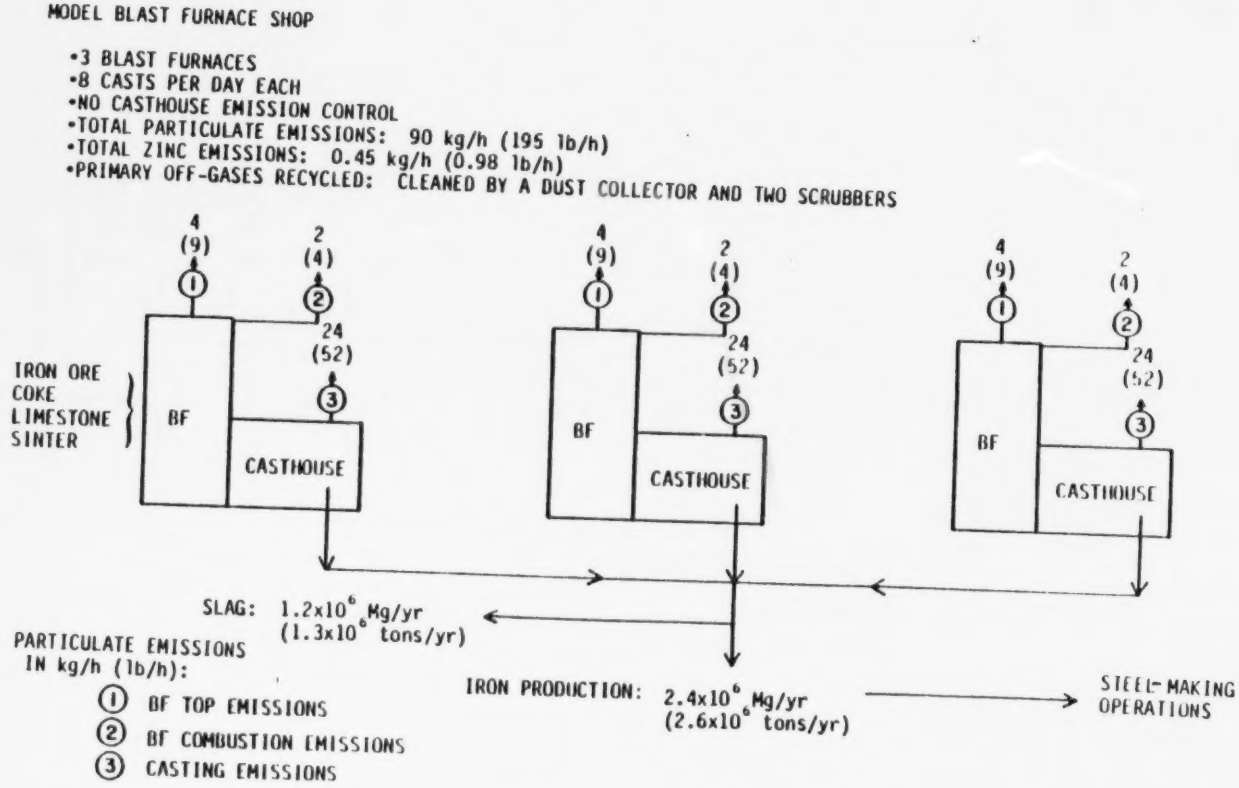

Figure 4-2. Model blast furnace plant for an integrated steel mill.[3]

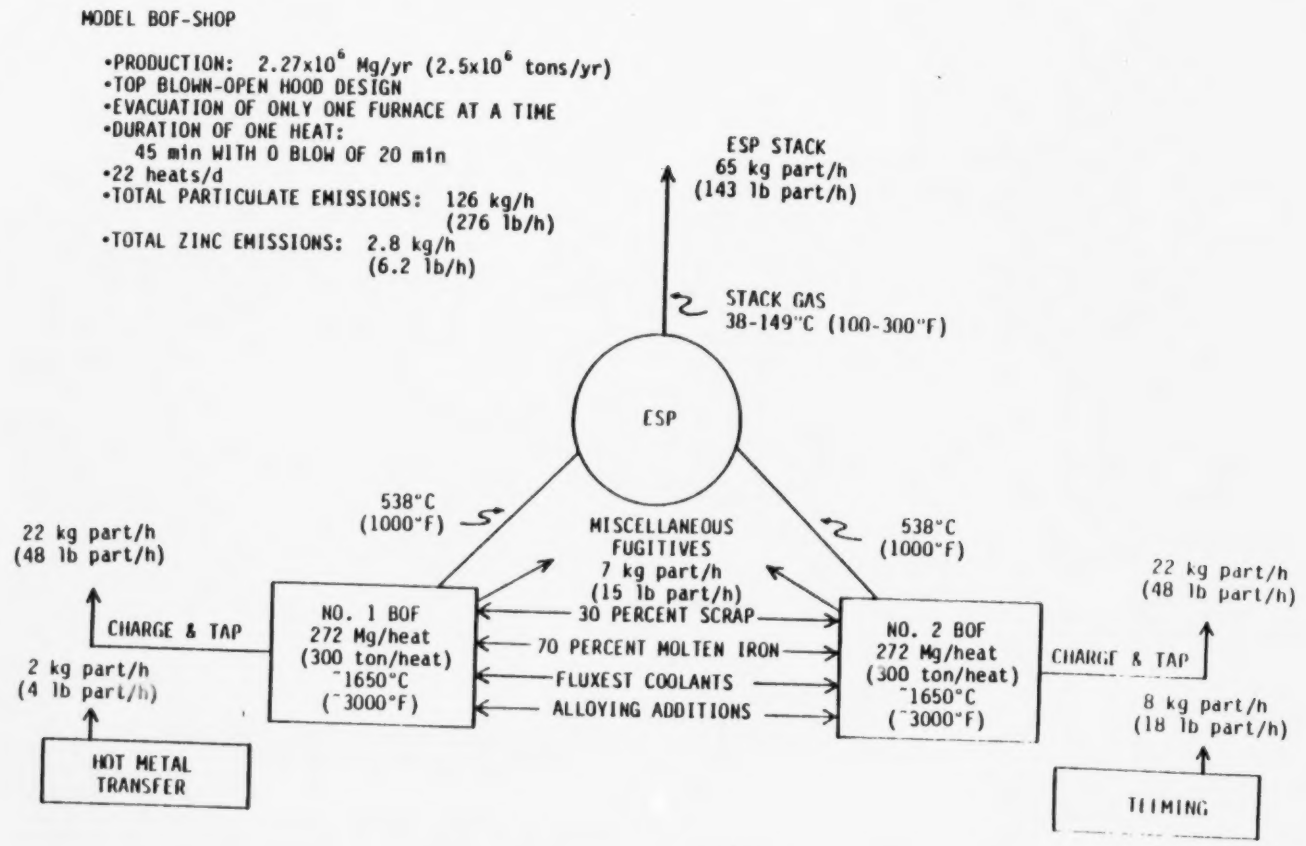

Figure 4-3. Model basic oxygen furnace shop for an integrated steel mill.[3]

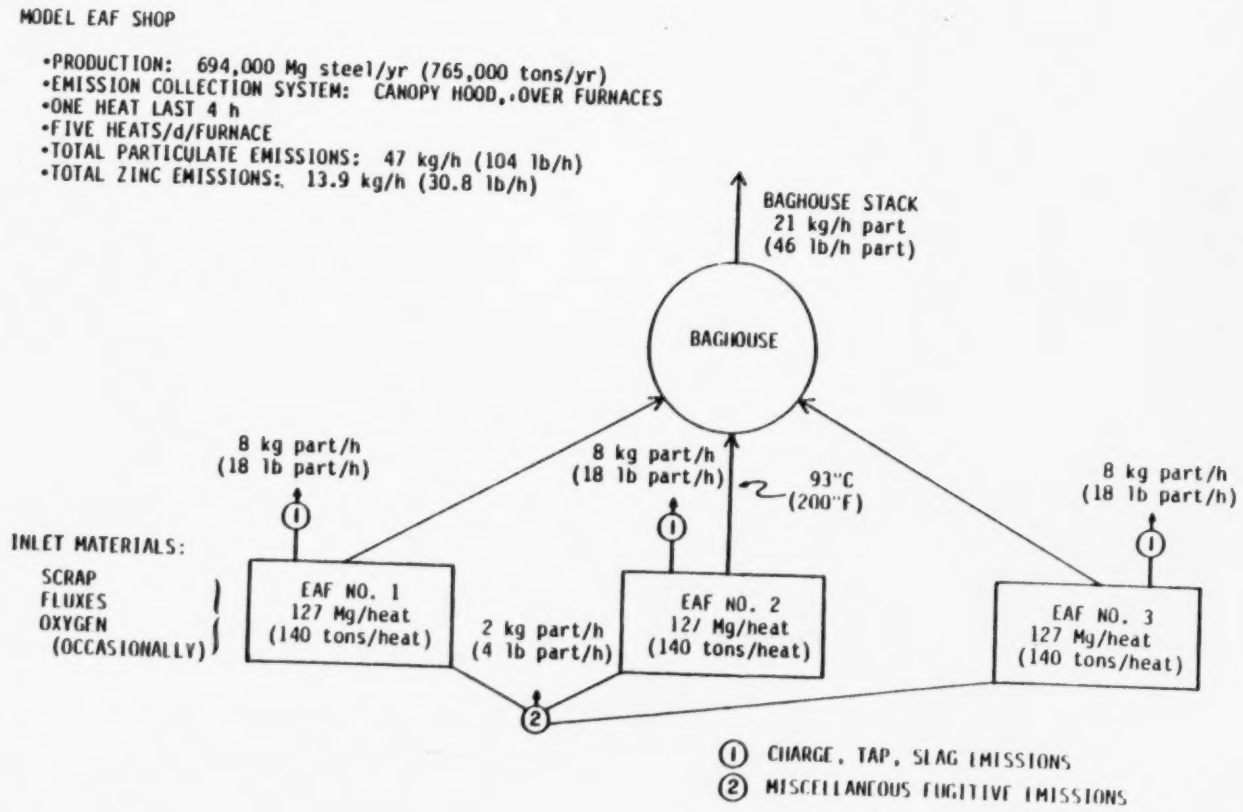

Figure 4-4. Model electric arc furnace shop in an integrated steel mill.[3]

MODEL OPEN HEARTH FURNACE SHOP

- PRODUCTION: 625,950 mg/yr (690,000 tons/yr)
- TAP TO TAP TIME: 9 h
- TOTAL PARTICULATE EMISSIONS: 31.3 kg/h (69 lb/h)
- TOTAL ZINC EMISSIONS: 3.9 kg/h (8.6 lb/h)

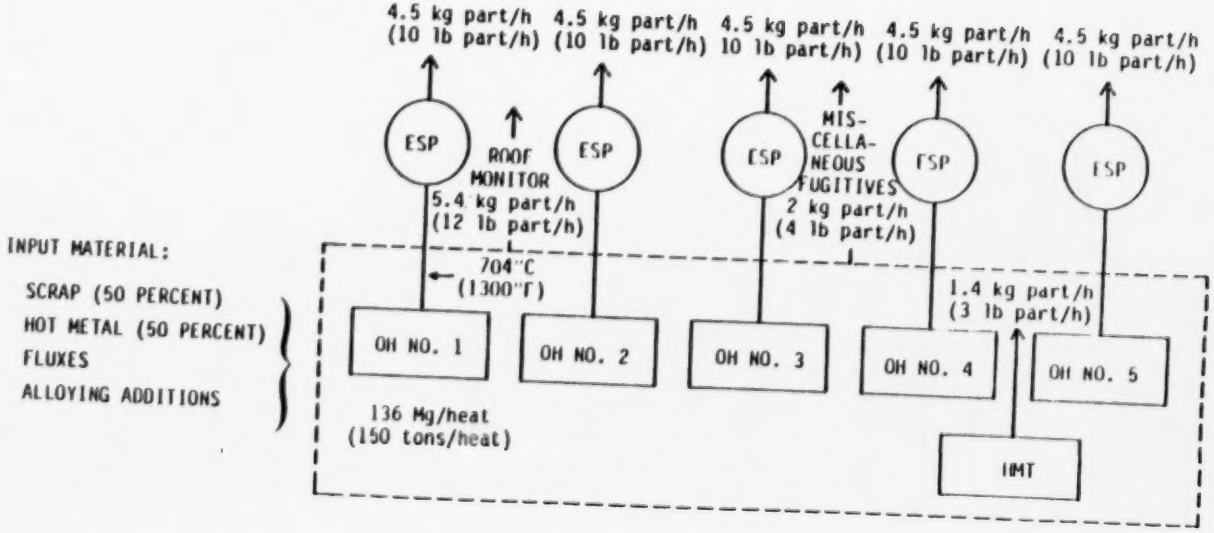

Figure 4-5. Model open hearth furnace shop in an integrated steel mill.[3]

TABLE 4-1. U.S. IRON AND STEEL PLANTS

Company/location
Integrated Steel Producers
U.S. Steel Corp., Fairfield, Ala.
Interlake, Inc., Lodi, Calif.
Cyclops Corp., Los Angeles, Calif.
Interlake, Inc., Pittsburg, Calif.
U.S. Steel Corp., Pittsburg, Calif.
Armco, Inc., Torrance, Calif.
CF&I Steel Corp., Pueblo, Colo.
LTV Steel Company, East Hartford, Conn.
Cyclops Corp., Hamden, Conn.
LTV Steel Company, Willimatic, Conn.
Armco, Inc. (Specialty Steels Division), Wildwood, Fla.
LTV Steel Company, Cedar Springs, Ga.
Interlake, Inc., Burr Ridge, Ill.
Inland Steel Company, Chicago, Ill.
Interlake, Inc., Chicago, Ill.
LTV Steel Company, Chicago, Ill.
U.S. Steel Corp., Chicago, Ill.
National Steel Corp., Granite City, Ill.
LTV Steel Company, Hennepin, Ill.
Interlake, Inc., Oak Brook, Ill.
Interlake, Inc., Oak Forest, Ill.
Interlake, Inc., Pontiac, Ill.
Bethlehem Steel Corp., Chesterton, Ind.
Inland Steel Company, East Chicago, Ind.
LTV Steel Company, East Chicago, Ind.
LTV Steel Company, Gary, Ind.
U.S. Steel Corp. Gary, Ind.
LTV Steel Company, Hammond, Ind.
National Steel Corp., Portage, Ind.
LTV Steel Company, Whiting, Ind.
Armco, Inc., Ashland, Ky.
Interlake, Inc., Shepardsville, Ky.
Armco, Inc., Baltimore, Md.
Bethlehem Steel Corp., Sparrows Point, Md.
Rouge Steel Company, Dearborn, Mich.
Sharon Steel Corp., Dearborn, Mich.
Cyclops Corp., Detroit, Mich.
LTV Steel Company, Detroit, Mich.
National Steel Corp., Ecorse, Mich.
LTV Steel Company, Ferndale, Mich.
McLouth Steel Products Corp., Gibralter, Mich.
McLouth Steel Products Corp., Trenton, Mich.
Cyclops Corp., Minneapolis, Minn.
Armco, Inc., Kansas City, Mo.
LTV Steel Company, Atco, N.J.

(continued)

TABLE 4-1. (continued)

Company/location
Integrated Steel Producers (continued)
Cyclops Corp., Elmwood Park, N.J.
Interlake, Inc., Riverton, N.J.
Interlake, Inc., Rockleigh, N.J.
Sharon Steel Corp., Union, N.J.
LTV Steel Company, Brooklyn, N.Y.
Cyclops Corp., Glen Cove, N.Y.
Bethlehem Steel Corp., Lackawanna, N.Y.
CF&I Steel Corp., New York, N.Y.
Cyclops Corp., Cambridge, Ohio
LTV Steel Company, Campbell, Ohio
LTV Steel Company, Canton, Ohio
LTV Steel Company, Cleveland, Ohio
Cyclops Corp., Coshocton, Ohio
Cyclops Corp., Dover, Ohio
LTV Steel Company, Elyria, Ohio
U.S. Steel Company, Lorain, Ohio
LTV Steel Company, Louisville, Ohio
Cyclops Corp., Mansfield, Ohio
Wheeling-Pittsburgh Steel Corp., Martins Ferry, Ohio
LTV Steel Company, Massillon, Ohio
Armco, Inc., Middletown, Ohio
Wheeling-Pittsburgh Steel Corp., Steubenville, Ohio
LTV Steel Company, Warren, Ohio
Sharon Steel Company, Warren, Ohio
Wheeling-Pittsburgh Steel Corp., Yorkville, Ohio
LTV Steel Company, Youngstown, Ohio
Armco, Inc., Zanesville, Ohio
Gilmore Steel Corp., Portland, Oreg.
LTV Steel Company, Aliquippa, Pa.
Wheeling-Pittsburgh Steel Corp., Allenport, Pa.
Armco, Inc., Ambridge, Pa.
LTV Steel Company, Beaver Falls, Pa.
Bethlehem Steel Corp., Bethlehem, Pa.
Cyclops Corp., Bridgeville, Pa.
Armco, Inc., Butler, Pa.
U.S. Steel Corp., Fairless Hills, Pa.
Sharon Steel Corp., Farrell, Pa.
Sharon Steel Corp., Greenville, Pa.
Cyclops Corp., Heidelberg, Pa.
U.S. Steel Corp., Homestead, Pa.
Bethlehem Steel Corp., Johnstown, Pa.
Bethlehem Steel Corp., Lebanon, Pa.
LTV Steel Company, Midland, Pa.
Wheeling-Pittsburgh Steel Corp., Monessen, Pa.
Cyclops Corp., Pittsburgh, Pa.
LTV Steel Company, Pittsburgh, Pa.

(continued)

TABLE 4-1. (continued)

Company/location
Integrated Steel Producers (continued)
National Steel Corp., Pittsburgh, Pa.
U.S. Steel Corp., Pittsburgh, Pa.
Wheeling-Pittsburgh Steel Corp., Pittsburgh, Pa.
Cyclops Corp., Sharon, Pa.
Sharon Steel Corp., Sharon, Pa.
Bethlehem Steel Corp., Steelton, Pa.
Sharon Steel Corp., Templeton, Pa.
Cyclops Corp., Titusville, Pa.
Bethlehem Steel Corp., Williamsport, Pa.
Interlake, Inc., Fountain Inn, S.C.
Interlake, Inc., Sumter, S.C.
LTV Steel Company, Counce, Tenn.
Interlake, Inc., Gallatin, Tenn.
U.S. Steel Corp., Baytown, Tex.
Lone Star Steel Company, Dallas, Tex.
Cyclops Corp., Houston, Tex.
Lone Star Steel Company, Lone Star, Tex.
U.S. Steel Corp., Provo, Utah
Bethlehem Steel Corp., Seattle, Wash.
Wheeling-Pittsburgh Steel Corp., Beech Bottom, W. Va.
Wheeling-Pittsburgh Steel Corp., Benwood, W. Va.
Weirton Steel Corp., Weirton, W. Va.
Wheeling-Pittsburgh Steel Corp., Wheeling, W. Va.
Interlake, Inc., Racine, Wis.
Specialty Producers
National Standard Company, Columbia, Ala.
Quanex Corp., Fort Smith, Ark.
Carpenter Tech. Corp., El Cajon, Calif.
California Steel Ind., Inc., Fontana, Calif.
Earle M. Jorgensen Company, Los Angeles, Calif.
Pacific Tube Company, Los Angeles, Calif.
Washington Steel Corp., Los Angeles, Calif.
Pinole Point Steel Company, Richmond, Calif.
The Atlantic Wire Company, Branford, Conn.
Carpenter Tech. Corp., Bridgeport, Conn.
Baines Group, Inc., Bristol, Conn.
Associated Spring, Bristol, Conn.
Wallace Baines Steel, Bristol, Conn.
Wallace Baines Steel, New Britain, Conn.
Wyckoff Steel, Putnam, Conn.
Allegheny Ludlum Steel Corp., Wallingford, Conn.
Phoenix Steel Corp., Claymont, Delaware
Laclede Steel Company, Alton, Ill.
Bliss & Laughlin Steel Company, Batavia, Ill.
Copperweld Corp., Chicago, Ill.

(continued)

TABLE 4-1. (continued)

Company/location
Specialty Producers (continued)
A. Finkl & Sons, Chicago, Ill.
KEYCON Industries, Inc.,
Wyckoff Steel, Chicago, Ill.
Welded Tube Company of America, Chicago, Ill.
Columbia Tool Steel Company, Chicago Heights, Ill.
Keystone Steel & Wire Company, Chicago Heights, Ill.
Pittsburgh Tube Company, Fairbury, Ill.
Thompson Steel Company, Inc., Franklin Park, Ill.
Bliss & Laughlin Steel Company, Harvey, Ill.
Continental Steel Corp., Joilet, Ill.
AXIA, Inc., Oak Brook, Ill.
Keystone Steel & Wire Company, Peoria, Ill.
Spencer Clark Metal Industries, Inc., South Holland, Ill.
Plymouth Tube Company, Winfield, Ill.
KEYCON Industries, Inc., Crawfordsville, Ill.
Slater Steels Corp., Fort Wayne, Ind.
Stanadyne, Western Steel Division, Gary, Ind.
La Salle Steel Company, Griffith, Ind.
Copperweld Corp., Hamlet, Ind.
La Salle Steel Company, Hammond, Ind.
Quanex Corp., Hammond, Ind.
Quanex Corp., Huntington, Ind.
Cabot Corp. Wrought Products Division, Kokomo, Ind.
Continental Steel Corp., Kokomo, Ind.
Indiana Steel & Wire Company, Muncie, Ind.
Ingersol Steel, Division of Avesta, Inc., New Castle, Ind.
National-Standard Company, Corbin, Ky.
Crucible Inc., Operating Corp., Elizabethtown, Ky.
Green River Steel Corp., Owensboro, Ky.
Copperweld Corp., Baltimore, Md.
Eastern Stainless Steel Company, Baltimore, Md.
Eastmet Corp., Cockeysville, Md.
Cumberland Steel Company, Cumberland, Md.
Thompson Steel Company, Inc., Sparrows Point, Md.
Thompson Steel Company, Inc., Canton, Mass.
Teledyne Rodney Metals, New Bedford, Mass.
Johnson Steel & Wire Company, Inc., Worcester, Mass.
G. F. Wright Steel & Wire Company, Worcester, Mass.
Quanex Corp., Ann Arbor, Mich.
Greer Steel Company, Detroit, Mich.
Whittar Steel Strip, Detroit, Mich.
Michigan Dynamics, Inc., Garden City, Mich.
Quanex Corp., MacSteel Division, Jackson, Mich.
Quanex Bar Group, Jackson, Mich.
National-Standard Company, Niles, Mich.

(continued)

TABLE 4-1. (continued)

Company/location
Specialty Producers (continued)
Wyckoff Steel, Plymouth, Mich.
Quanex Corp., S. Lyon, Mich.
Delta Wire Corp., Clarksdale, Miss.
Laclede Steel Company, St. Louis, Mo.
Missouri Rolling Mill Corp., St. Louis, Mo.
Quanex Corp., Verdie, N.Y.
National Standard Company, Clifton, N.J.
Wheatland Tube Company, Collingswood, N.J.
Quanex Corp., South Plainfield, N.J.
Carpenter Tech. Corp., Union, N.J.
Gibralter Steel Corp., Buffalo, N.Y.
Ramco/Fitzsimons Steel Company, Inc., Buffalo, N.Y.
Seneca Steel Corp., Buffalo, N.Y.
CAX, Inc., Carle Place, N.Y.
Al Tech Specialty Steel Corp., Dunkirk, N.Y.
Electralloy Corp., New York, N.Y.
Copperweld Corp., Oswego, N.Y.
Rome Strip Steel Company, Inc., Rome, N.Y.
Crucible Inc., Operating Corp., Syracuse, N.Y.
Al Tech Specialty Steel Corp., Watervliet, N.Y.
Babcock & Wilcox Company, Alliance, Ohio
Latrobe Steel Company, Bowling Green, Ohio
The Timken Company, Canton, Ohio
Mid America Steel Corp., Cleveland, Ohio
The Timken Company, Columbus, Ohio
Grier Steel Company, Dover, Ohio
Stanadyne, Western Steel Division, Elyria, Ohio
Seneca Wire and Manufacturing Company, Fostoria, Ohio
McDonald Steel Corp., McDonald, Ohio
Bliss & Laughlin Steel Company, Medina, Ohio
The Champion Steel Company, Orwell, Ohio
Copperweld Corp., Shelby, Ohio
Quanex Corp., Shelby, Ohio
Cuyahoga Steel & Wire, Inc., Solon, Ohio
Baron Drawn Steel Corp., Toledo, Ohio
Copperweld Corp., Warren, Ohio
Thomas Steel Strip Corp., Warren, Ohio
Latrobe Steel Company, Wauseon, Ohio
The Timken Company, Wooster, Ohio
Allegheny Ludlum Steel Corp., Claremore, Okla.
National-Standard Company, Stillwater, Okla.
Babcock & Wilcox Company, Beaver Falls, Pa.
Moltrup Steel Products Company, Beaver Falls, Pa.
Allegheny Ludlum Steel Corp., Brackenridge, Pa.
Standard Steel, Burnham, Pa.

(continued)

TABLE 4-1. (continued)

Company/location
Specialty Producers (continued)
Teledyne Columbia-Summerville, Carnegie, Pa.
Lukens, Inc., Steel Division, Coatesville, Pa.
Lukens Conshohocken, Conshohocken, Pa.
McInnes Steel Company, Corry, Pa.
Pittsburgh Tube Company, Darlington, Pa.
Washington Steel Corp., Darlington, Pa.
Fitch Works--Hot Metal Plant, Houston, Pa.
Fitch Works--Hot Strip Mill, Houston, Pa.
Jersey Shore Steel Company, Jersey Shore, Pa.
Latrobe Steel Company, Latrobe, Pa.
Standard Steel, Latrobe, Pa.
Teledyne Vasco, Latrobe, Pa.
Braeburn Alloy Steel Division, Lower Burrell, Pa.
CCX, Inc., Lower Burrell, Pa.
National Rolling Mills, Inc., Malvein, Pa.
Pittsburgh Tube Company, Monaca, Pa.
Superior Drawn Steel Company, Monaca, Pa.
Teledyne Pittsburgh Tool Steel, Monaca, Pa.
Teledyne Vasco, Monaca, Pa.
National-Standard Company, Mount Joy, Pa.
Allegheny Ludlum Steel Corp., Natrona Heights, Pa.
Blair Strip Steel Company, New Castle, Pa.
Elliott Brothers Steel Company, New Castle, Pa.
Edgewater Corp., Oakmont, Pa.
Electralloy Corp., Oil City, Pa.
Phoenix Steel Corp., Phoenixville, Pa.
Allegheny Ludlum Steel Corp., Pittsburgh, Pa.
Copperweld, Corp., Pittsburgh, Pa.
Alumoweld Products Division, Pittsburgh, Pa.
Cyclops Corp., Pittsburgh, Pa.
Wyckoff Steel, Pittsburgh, Pa.
Carpenter Tech. Corp., Reading, Pa.
Teledyne Columbia-Summerill, Scottdale, Pa.
Sharon Tube Company, Sharon, Pa.
Jersey Shore Steel Company, South Avis, Pa.
La Salle Steel Company, Spring City, Pa.
Quanex Corp., Spring City, Pa.
Jessop Steel Company, Washington, Pa.
Washington Steel Corp., Washington, Pa.
Allegheny Ludlum Steel Corp., W. Leechburg, Pa.
Wheatland Tube Company, Wheatland, Pa.
Newman-Crosby Steel, Inc., Pawtucket, R.I.
Carpenter Tech. Corp., Orangeburg, S.C.
Copperweld Corp., Fayetteville, Tenn.
Chromium Mining and Smelting Corp., Memphis, Tenn.

(continued)

TABLE 4-1. (continued)

Company/location
Specialty Producers (continued)
Quanex Corp., Bellville, Tex.
Babcock & Wilcox Company, Bryan, Tex.
KEYCON Industries, Inc., Dallas, Tex.
Keystone Consolidated Industries, Inc., Dallas, Tex.
Cameron Iron Works, Inc., Houston, Tex.
Hurricane Industries, Inc., Houston, Tex.
Quanex Corp., Houston, Tex.
Hurricane Industries, Inc., LaGrange, Tex.
Texas General Steel Company, Inc., Lubbock, Tex.
Ingersol Rand Specialty Steel Division, Pampa, Tex.
Quanex Corp., Rosenburg, Tex.
Hurricane Industries, Inc., Sealy, Tex.
KEYCON Indsutries, Inc., Sherman, Tex.
Earle M. Jorgensen Company, Seattle, Wash.
Pittsburgh Tube Company, Jane Lew, W. Va.
Crucible, Inc., Operating Corp., E. Troy, Wis.
Mini Plants
Birmingham Bolt Company, Birminham, Ala.
SMI Steel, Inc., Birmingham, Ala.
Marathon Steel Company, Phoenix, Ariz.
Marathon Steel Company, Tempe, Ariz.
Razorback Steel Corp., Newport, Ark.
Soule Steel Company, Carson, Calif.
Judson Steel Corp., Emeryville, Calif.
TAMCO, Etiwanda, Calif.
Marathon Steel Company, Santa Fe Springs, Calif.
Soule Steel Company, Walnut Creek, Calif.
Connecticut Steel Corp., Wallingford, Calif.
Florida Steel Corp., Baldwin, Fla.
Florida Steel Corp., Ft. Lauderdale, Fla.
Florida Steel Corp., Ft. Meyers, Fla.
Florida Steel Corp., Indiantown, Fla.
Florida Steel Corp., Jacksonville, Fla.
Florida Steel Corp., Orlando, Fla.
Florida Steel Corp., Tampa, Fla.
Florida Transportation Division, Tampa, Fla.
Tampa Reinforcing Steel Plant, Tampa, Fla.
Tampa Steel Mill, Tampa, Fla.
Atlantic Steel Company, Atlanta, Ga.
Atlanta Steel Company, Cartersville, Ga
Florida Steel Corp., Duluth, Ga.
Hawaiian Western Steel, Ltd, SubWestern Canada Steel Division, Ewa, Hawaii

(continued)

TABLE 4-1. (continued)

Company/location
Mini Plants (continued)
Birmingham Bolt Company, Bourbonnais, Ill.
Wire Sales Company, Chicago, Ill.
B. W. Steel, Inc., Chicago Heights, Ill.
Calumet Steel Company, Chicago Heights, Ill.
Thomas Steel Corp., Lemont, Ill.
Northwestern Steel & Wire Company, Sterling, Ill.
North Star Steel Company, Wilton, Iowa
Kentucky Electric Steel Company, Ashland, Ky.
Ohio River Steel Corp., Calvert City, Ky.
Newport Steel Corp., Newport, Ky.
Bayou Steel Corp., LaPlace, La.
Florida Steel Corp., Slidell, La.
North Star Steel Company, Monroe, Mich.
North Star Steel Company, Duluth, Minn.
North Star Steel Company, Minneapolis, Minn.
North Star Steel Company, St. Paul, Minn.
Mississippi Steel, Division of Magna Corp., Jackson, Miss.
Raritan River Steel Company, Perth Amboy, N.J.
N.J. Steel Corp., Sayreville, N.J.
Roblin Steel Company, N. Tonawanda, N.Y.
Roblin Steel Company, Dunkirk, N.Y.
Robin Steel Company, North Tonawanda, N.Y.
Florida Steel Corp., Charlotte, N.C.
Nucor Corp., Charlotte, N.C.
Florida Steel Corp., Raleigh, N.C.
N.B. Steel Mill, Inc., Cincinnati, Ohio
Marion Steel Company, Marion, Ohio
Oklahoma Steel Mill, Inc., Oklahoma City, Okla.
Sheffield Steel Corp., Sand Springs, Okla.
Cascade Steel Rolling Mills, Inc., McMinnville, Oreg.
Ameri-Steel Company, Carnegie, Pa.
Franklin Steel, Franklin, Pa.
Milton Manufacturing Company, Milton, Pa.
Ameri-Steel, Uniontown, Pa.
Florida Steel Corp., Aiken, S.C.
Georgetown Steel Corp., Andrews, S.C.
Owen Electric Steel Company of S.C., Columbia, S.C.
Georgetown Steel Corp., Georgetown, S.C.
Georgetown Steel Corp., Gallatin, Tenn.
Florida Steel Corp., Jackson, Tenn.
Knoxville Iron Company, Inc., Knoxville, Tenn.
Knoxville Iron Company, Inc., Rockwood, Tenn.
North Star Steel Company, Beaumont, Tex.
Border Steel Mills, Inc., El Paso, Tex.
Texas Steel Company, Ft. Worth, Tex.

(continued)

TABLE 4-1. (continued)

Company/location
Mini Plants (continued)
Marathon Steel Company, Houston, Tex.
Marathon LeTourneau Company, Longview, Tex.
Chaparral Steel Company, Midlothian, Tex.
Structural Metals, Inc., Seguin, Tex.
Marathon Steel Company, Salt Lake City, Utah
Intercoastal Steel Corp., Chesapeake, Va.
Roanoke Electric Steel Corp., Roanoke, Va.
Northwest Steel Rolling Mills, Inc., Seattle, Wash.
Charter Rolling, Division of Charter Manufacturing, Inc., Saukville, Wis.

[a]Net ingots.
[b]Cold melt electric furnace steel.
[c]Tons bars and tubes.
[d]Tons pipe and tubing.
[e]Tons galvanized pipe and tubing.
[f]Tons billets.
[g]Tons merchant and special bar quality rolled products.

TABLE 4-2. CHEMICAL ANALYSIS OF THE FUMES COLLECTED BY A BAGHOUSE AND AN ESP FROM ZINC GALVANIZING KETTLES[5]

Component	Fumes collected in a baghouse (job shop kettle), weight percent	Fumes collected in an ESP (chain link galvanizing), weight percent
NH_4Cl	68.0	23.5
ZnO	15.8	6.5
$ZnCl_2$	3.6	15.2
Zn	4.9	--
NH_3	1.0	3.0
Oil	1.4	41.4
H_2O	2.5	1.2
C	2.8	--
Not identified	--	9.2

4.4 REFERENCES FOR CHAPTER 4

1. Directory, Iron and Steel Plants, 1985. Published by Association of Iron and Steel Engineers. Pittsburgh, Pennsylvania. 616 p.

2. National Inventory of Sources and Emissions: Barium, Boron, Copper, Selenium and Zinc. Section V, Zinc. U. S. Environmental Protection Agency, NTIS Document No. PB 210 680. May 1972. pp. 32-37, 66-69.

3. Survey of Cadmium Emission Sources. GCA Corporation, EPA 450/3-81-013. September 1981. pp. 105-132.

4. Cuscino, T. A. Particulate Emission Factors Applicable to the Iron and Steel Industry. Midwest Research Institute. U. S. Environmental Protection Agency, Research Triangle Park, North Carolina. EPA 450/4-79-028. September 1979.

5. Air Pollution Engineering Manual. Public Health Service Publication No. 999-AP40. p. 405. 1967. (In Reference 2, p. 36).

6. Characterization, Recovery, and Recycling of Electric Arc Furnace Dusts. Lehigh University. Bethlehem, Pennsylvania. Prepared for U.S. Department of Commerce. February 1982. 7 pp.

5. MISCELLANEOUS ZINC EMISSION SOURCES

5.1 BACKGROUND INFORMATION

The following sections discuss miscellaneous sources of zinc emissions. Where available, emission factors and nationwide emission estimates are provided.

5.1.1 Zinc-Base Alloys

According to 1985 production data, zinc-base alloys consumed 25 percent or 177,500 megagrams (Mg) [195,700 tons] of total zinc.[1]

Aluminum is the major alloying constituent and is used in quantities ranging from 3.5 to 4.3 percent. A zinc-aluminum alloy exhibits increased strength and slows the attack of the alloy on iron and steel parts.[2] Alternatively, zinc may be added to copper in concentrations of 5 to 40 percent to form the alloy series known as the brasses. Zinc increases both tensile strength and hardness of the copper alloy. Zinc, in concentrations of up to 5 percent, may be added to tin-bronze alloys to tighten the structure and act as a deoxidizer.[3]

Virgin metals are preferred for the manufacture of the alloys for die casting. The procedure itself is usually accomplished in a pot or reverberatory furnace. The alloy is cast into bars that fill the melting pots at the die-casting machine.[4] The alloy is then melted in pots that range in size from 910 to 3,640 kilograms (Kg) [2,000 to 8,000 pounds (lb)]. The temperature of the metal in the pots is typically 150° to 200°C (300° to 400°F) and should not exceed 430°C (800°F). The molten metal flows from the pots into an adjacent cylinder. A plunger is forced down into the cylinder, and the overflow liquid is displaced into a stainless steel die, which is filled at temperatures up to 510°C (950°F). The operator then opens the die and removes the casting.[4]

An alternative casting method, thin wall die casting, was developed in the late 1970's in response to a demand in the automotive market for lighter materials. This method reduces the thickness of the casting wall and results in a 30 to 50 percent reduction in casting weight.[5]

At most plants, the scrap generated during die-casting operations is remelted, cleaned, and reused.[6]

5.1.2 Zinc Electroplating

Zinc plating is a commonly used electroplated finish for the corrosion protection of iron and steel. Zinc offers "sacrificial" protection of ferrous metals because it is anodic to the substrate; the latter is protected so long as some zinc remains in the immediate area. Zinc may be plated on continuous sheet and wire, conduit, and all types of hardware such as tools, nuts, bolts, and screws.[7,8]

A cyanide bath is use for general plating. However, zinc chloride, sulfate, and fluoborate baths are used in strip and wire plating because they are capable of higher plating speeds. These and other alternative baths may be used to meet EPA regulations to reduce or eliminate cyanide in the effluent.[7,8]

5.1.3 Rolled Zinc

Production of rolled zinc accounted for 6 percent of 1985 zinc consumption.[9] Rolled zinc is used in photoengraving, lithography, dry cells, weather stripping, and many building applications. It can take the form of sheet, strip, plate, rod, and wire and is composed of high-grade zinc to which alloying metals such as copper, magnesium, manganese, chromium, and titanium are added in controlled amounts. A zinc content of 99.8 percent or more gives good drawing characteristics and the alloy additions provide a material with a wide range of tempers and strengths.[10]

The zinc and its alloying elements are usually melted in a reverberatory furnace although induction furnaces may be used when careful product control is necessary. The furnace temperature for melting is about 450° to 510°C (850° to 950°F). After melting, the zinc is cast into molds for rolling slabs which are heated to 150° to 260°C (300° to 500°F) depending on the final product. The rate of reduction during rolling is determined by the analysis of the metal, the type of equipment, and the desired finish.[10]

5.1.4 Other Miscellaneous Sources

In 1985, other miscellaneous sources of zinc consumption accounted for 6 percent or 9,440 Mg (8,560 tons) of total zinc.[11] This estimate includes consumption in paints, which are discussed in Chapter 6, Miscellaneous Zinc Oxide Sources. Miscellaneous sources addressed below are lead desilvering, zinc batteries, and light metal alloys.

In the desilvering of lead, the lead bullion gives up its silver content to zinc. In general, the two processes used include the "stirring-in" of zinc, cooling, skimming silver-zinc crusts, and distillation of crusts.[12]

Zinc is used as the anode of various "wet" batteries such as the Lalande cell, Eveready air cell, National Carbon air cell, and silver-zinc batteries.[13] Nickel-zinc batteries are currently being investigated for potential commercial use in rechargable, electric vehicles.[14]

Zinc is a secondary or minor ingredient in many light metal alloys, including both the cast and wrought alloys of aluminum and magnesium. It is also frequently alloyed with tin in aluminum solders, Britannia metal, pewter, and "Queen's metal." In silver solders, the zinc content ranges from about 5 to 40 percent.[15]

5.2 EMISSIONS

5.2.1 Zinc-Base Alloys

According to available information, the scrap reclamation operation is the major source of zinc emissions to the atmosphere.[16] Induced draft ventilation systems are used, but there is no dust or fume collection equipment. Information obtained from die-casting companies indicated that average emissions equal 10 lb per ton of zinc processed in 1969 although the range of emissions was from much less than 10 to up to 60 lb per ton.[16] However, it is not known if the same emission factors would apply to thin wall technology (more or less scrap could be generated). It is also possible that plants are better controlled today than they were in 1969.

5.2.2 Zinc Electroplating

Emissions to the atmosphere due to electrolytic deposition of zinc are considered negligible.[17] The EPA Air Pollution Engineering Manual

(AP-40) notes that, with the exception of chromium plating processes, most of the electrolytic plating and cleaning processes are of little interest from a standpoint of air pollution because the emissions are inoffensive and of negligible volume because of low gassing rates.[18]

5.2.3 Rolled Zinc

According to currently available information, zinc emissions from rolled zinc are negligible.[19]

5.2.4 Other Miscellaneous Sources

Estimates of zinc emissions to the atmosphere from miscellaneous uses of zinc were developed in a previous study almost entirely without assistance from industrial sources. Only two manufacturers provided emission estimates. More than 30 others stated that their emissions were negligible; however, some defined negligible emissions as less than 1 percent loss of raw material. It is apparent that there are some losses to the atmosphere during the desilverizing of lead and alloying as well as in operations using smaller quantities of zinc. During 1969, zinc emissions to the atmosphere due to processing and manufacturing operations were estimated at 100 tons, or approximately 0.001 percent of the zinc consumed for such miscellaneous purposes.[20]

5.3 REFERENCES FOR CHAPTER 5

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6. MISCELLANEOUS ZINC OXIDE EMISSION SOURCES

6.1 BACKGROUND INFORMATION

The following sections discuss miscellaneous sources of zinc oxide emissions. Emissions from production of zinc oxide are discussed in Chapter 2. Table 1 presents distribution of zinc oxide shipments, by industry, in 1984.[1]

6.1.1 Rubber Production

The largest use of zinc oxide at the present time is in rubber products. Vulcanizing accelerators such as aldehyde-amines, guianidines, and thiuram sulfides are used to decrease the time and temperature required for vulcanization, and zinc oxide is one of a series of accelerator activators used to supplement the accelerators. Zinc oxide also helps to modify finished product characteristics such as resistance to ultraviolet (UV) light and increased elasticity.[2,3]

During the manufacturing process, the additives to be compounded into the rubber must be homogeneously dispersed throughout the blend. Rubber mills and Banbury mixers are the principal types of equipment used for this purpose.[3]

6.1.2 Photocopying

The second largest use of zinc oxide is in photocopying owing to the photoconductive and electrostatic properties of zinc oxide. Conventional printing paper is coated with zinc oxide powder that is dye-sensitized by adsorption to extend its photosensitivity across the visible region. The copy is made by placing the material to be reproduced between a light source and the charged paper. Where the light passes through to the zinc oxide paper, the electrostatic charge is dissipated. The image is developed by applying a pigmented resin powder that adheres only to the areas where the electrostatic charge has not been removed. The image is fixed to the paper by heat.[4,5]

TABLE 6-1. DISTRIBUTION OF ZINC OXIDE SHIPMENTS, BY INDUSTRY, 1984

Industry	Shipments	
	Mg	(Tons)
Agriculture	2,380	(2,624)
Ceramics	7,472	(8,237)
Chemicals	23,611	(26,027)
Paints	8,117	(9,014)
Photocopying	9,246	(10,192)
Rubber	79,390	(87,513)
Other	16,702	(18,411)
TOTAL	146,918	(162,018)

6.1.3 Zinc Paints

Zinc oxide is an additive in paints for exterior wood surfaces. It aids in mixing and grinding, improves drying and hardening of the paint film, reduces paint discoloration, improves mildew resistance and self-cleaning, and reduces chalking. Emulsion-type latex paints for use on cement and masonry surfaces also require the use of zinc oxide for the same purpose as oil-base paints, with the added benefit of helping to reduce container corrosion.[6]

Zinc paints are particularly important in applications where it is necessary to protect steel from oxidation. In 1978, this market segment accounted for approximately 11 percent of the total zinc consumed in zinc coatings. With lead being virtually eliminated as a paint pigment, zinc paints are expected to achieve an annual growth rate of 5 percent per year through the 1980's.[7]

At the paint factory, the zinc oxide is received in paper sacks and emptied into vats containing a liquid. There is a small amount of dust generated as the sacks are emptied, but most plants are equipped with ventilation systems.[8]

6.1.4 Other Miscellaneous Sources

According to one study, the other miscellaneous uses of zinc oxide accounted for approximately 23 percent of total consumption in 1969.[9] In ceramics and glass (including glazes, enamels, and frits) it is an essential ingredient. In glass it reduces the melting time, lowers viscosity, and raises chemical and mechanical resistance. Up to 15 percent zinc oxide may be used for heat-resisting glass, technical glass, optical glass, selenium ruby glass, and yellow nickel glass. For special purposes, the zinc oxide content may go up to 50 percent.[9]

In glazes it contributes to fusibility, increases resistance to thermal and mechanical shock, improves luster, and enhances opacity. In porcelain enamels for sheet iron and vitreous enamels for cast iron it contributes to electrical resistivity. These enamels are used extensively on refrigerators, ranges, washers, sinks, and toilet fixtures.[9]

Zinc oxide, because it is an opaque material that blocks and scatters light, is used as a mechanical sunscreen barrier.[10] Zinc oxide is also used in combination with eugenol to form impression and surgical pastes

used in dental work.[11] Another use of zinc oxide is as an industrial anticaking agent to control storage properties and retain the freeflow characteristics of crystalline masses.[12] Finally, zinc oxide is used as a stabilizer against UV radiation in plastics and feed additives, floor coverings, soaps, and other products.[13,14]

6.2 EMISSIONS

6.2.1 Rubber Production

Some zinc oxide emissions, in the form of finely ground particulates (less than 15 micrometers), occur while charging the mills or mixers or at the blending stage. Mills and mixers typically are controlled with baghouses that are capable of operating with 98 to 99.5 percent efficiency.[15] The more significant source of emissions occurs during wear of vehicle tires. According to one study, the usual dosage of zinc oxide is in the range of 60 to 100 pounds (lb) per ton of rubber, and the average quantity per vehicle tire has been reported to be about 0.5 lb. Assuming a 20 percent wear-rate, an average tire life of 20,000 miles, and 1.05×10^{12} miles traveled per year, the zinc emissions from tire wear during the year of the study (1969) total 8,400 tons.[16]

6.2.2 Photocopying

Emissions from zinc oxide coated paper result primarily from the burning of discarded copies.[17] Zinc oxide is applied to printing paper in a paint form. Therefore, the manufacture of zinc oxide coated paper is unlikely to be a major source of zinc oxide emissions.

6.2.3 Zinc Paints

Zinc oxide emissions occur when the zinc oxide dust is emptied into the mixing vats. In addition, some dust may remain in the empty bags that are either burned or discarded with the trash. According to one study, no emission records were available at paint factories, but the authors estimated that atmospheric emissions of zinc oxide do not exceed 1 lb per ton of zinc oxide processed.[18]

6.2.4 Other Miscellaneous Sources

The principal sources of zinc emissions during the making of glass, glazes, and enamels are the initial dry mixing operation and the melting furnaces. Emission sources for the other miscellaneous uses are not

known, but it is thought that overall emissions are low considering the fact that these sources account for less than 0.3 percent of total zinc use.[19]

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APPENDIX

This appendix contains two sets of HEM information. The first set contains HEM data for sources in the primary zinc/zinc oxide industry taken from the cadmium Phase I project. Zinc and zinc oxide emissions for these sources were calculated using emission factors developed from test data and Section 114 responses obtained during the cadmium project.

The second set contains HEM data as obtained from permits from the States of New York, Kentucky, and Illinois. The majority of the data are from New York, and the following assumptions or changes were made to these data:

1. Three plants (General Electric, Olin Corp., and F. R. Manufacturing, Inc.) reported stack temperatures of 8°F. This seemed to be an error, and temperatures of 70°F (Olin) and 120°F (GE and F. R. Manufacturing) were substituted as being more representative of the processes involved.

2. One company (Flomatic) reported a stack height of 6 feet. However, closer inspection of the permit revealed that 25 feet was more likely correct. (The company had reported a 6-feet-high stack that was 25 feet higher than the closest building. It was assumed that the correct interpretation is a 25-foot stack that is 6 feet higher than the closest building.)

3. Some companies reported the dimensions of a square stack (26x26 for example). In this case, the area of the cross section was calculated and the equivalent diameter of a circular stack was calculated and used as the HEM input value.

4. Companies reporting <1 lb/yr of emissions were deleted as were lightweight aggregate producers and one municipal incinerator. The processes in the latter cases were assumed to be atypical zinc/zinc oxide

emission sources. Inspection of the permit for lightweight aggregate producers revealed the use of a waste solvent as fuel that contained traces of zinc. The municipal incinerator was eliminated because it did not fit any of the source categories under study.

The following assumptions/decisions were made regarding permit information from other States:

1. For the State of Illinois, only one source was included (zinc oxide emissions from paint manufacturing at Sherwin Williams) because all other data were either for TSP or were incomplete. A printout of the data received from Illinois is attached.

2. Latitudes and longitudes were computed from the UTM coordinates reported in the permits using a BASIC computer program obtained from MDAD/PAB.

3. The emission source at Bluegrass Plating (Kentucky) was assumed to be an area source of 0.001 km^2. The permit listed an area of zero.

HEM input parameters for primary zinc/zinc oxide smelters.

PLANT NAME	POLLUTANT	LATITUDE	LONGITUDE	STATE	TYPE	STACK NUMBER	HEIGHT M	AREA SQ.M	DIAM. M	VELOCITY M/S	TEMP. K	EMISSIONS, KG/YR	DESCRIPTION
AMAX ZINC CO.	Zinc	383611	901013	IL	H	2	22.86	10.45	0.457	29.565	383	560.890	ZN MELT FURN BH
AMAX ZINC CO.	Zinc	383611	901013	IL	F	3	0.00	0.00	0.000	0.000	294	5608.860	ZN TAP/CAST FUGS
AMAX ZINC CO.	Zinc	383611	901013	IL	H	4	10.36	5.52	0.530	16.1	294	19059.970	ZN DUST PROCESS BH
JERSEY MINIERE ZINC	Zinc oxide	363100	872430	TN	H	2	30.48	7.41	0.405	9.886	294	1026.880	CALCINE BH
JERSEY MINIERE ZINC	Zinc	363100	872430	TN	H	3	15.85	14.49	0.914	11.203	327	670.290	ZN MELT FURN
JERSEY MINIERE ZINC	Zinc	363100	872430	TN	H	4	15.24	13.93	0.914	9.170	294	1748.330	ZN METAL POWDER BH
JERSEY MINIERE ZINC	Zinc	363100	872430	TN	F	5	0.00	0.00	0.000	0.000	294	6702.900	ZINC TAP/CAST
NATIONAL ZINC	Zinc	364436	955932	OK	H	2	0.00	0.00	0.000	0.000	294	3962.700	ZN TAP/CAST
NATIONAL ZINC	Zinc	364436	955932	OK	F	3	14.02	5.13	0.366	20.213	322	1655.000	ZN METAL POWDER BH
NATIONAL ZINC	Zinc	364436	955932	OK	H	5	13.11	7.19	0.543	21.960	322	396.270	ZN MELTING FURNACE
ST. JOE RESOURCES	Zinc	404014	802011	PA	H	3	19.20	9.75	0.508	9.389	339	476.450	ZN HOLDING FURNACE
ST. JOE RESOURCES	Zinc	404014	802011	PA	H	4	0.00	0.00	0.000	0.000	294	4764.510	ZN TAP/CAST
ST. JOE RESOURCES	Zinc oxide	404014	802011	PA	H	5	18.29	16.72	0.914	3.597	341	108.860	ZN METAL POWDER BH
ST. JOE RESOURCES	Zinc oxide	404014	802011	PA	H	6	121.92	658.84	5.404	5.001	359	14814.340	SINTER MACHINES BH
ST. JOE RESOURCES	Zinc oxide	404014	802011	PA	H	7	36.88	78.69	2.134	17.028	335	35359.000	SINTER SIZE/CRUSH BH
ST. JOE RESOURCES	Zinc	404014	802011	PA	H	8	60.96	204.39	3.353	12.295	309	63042.000	ZN FURN PREHEAT BH
ST. JOE RESOURCES	Zinc oxide	404014	802011	PA	H	9	22.86	27.87	1.219	13.346	408	2013.950	REFINING COL BH #1
ST. JOE RESOURCES	Zinc	404014	802011	PA	H	10	14.33	19.65	1.372	17.569	408	25900.000	ZNO FURN BHS
ST. JOE RESOURCES	Zinc	404014	802011	PA	H	12	22.86	24.39	1.067	17.424	408	2013.950	REFINING COL BH #2
NJ ZINC EAST PLANT	Zinc oxide	404014	802011	PA	H	13	18.29	16.72	0.914	11.068	294	108.860	NUISANCE ZN DUST BH
NJ ZINC EAST PLANT	Zinc oxide	404840	753520	PA	H	2	9.10	10.92	1.200	17.400	466	168.980	WEALZ KILN FUGS BH
NJ ZINC EAST PLANT	Zinc oxide	404840	753520	PA	H	3	24.40	122.00	5.000	7.300	411	27918.490	WEALZ KILN PROD BH
NJ ZINC EAST PLANT	Zinc oxide	404840	753520	PA	H	4	15.20	23.16	1.524	10.868	307	2737.250	SINTER BH
NJ ZINC EAST PLANT	Zinc oxide	404840	753520	PA	H	5	13.11	18.04	1.376	14.924	497	1061.480	FUME KILN BH
		404840	75352	PA	H	6	22.90	52.67	2.300	7.300	355	26388.220	MOVING GRATE FURNACE BAGHOUSE

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State Permit Data
HEM Input Parameters
ZINC

UPDATE	POLLUTANT	SOURCE CATEGORY	PLANT NO.	SIC CODE	PLANT NAME	LATITUDE	LONGITUDE	URBAN	CITY	STATE	TYPE
09/26/86	Zinc	Brass/Bronze	2	3361	FR Manufacturing, Inc	423240	790953	0	Silver Creek	NY	H
09/26/86	Zinc	Brass/Bronze	2	3361	FR Manufacturing, Inc	423240	790953	0	Silver Creek	NY	H
09/26/86	Zinc	Brass/Bronze	2	3361	FR Manufacturing, Inc	423240	790953	0	Silver Creek	NY	H
09/26/86	Zinc	Pigments/Paints	3	2851	Pratt & Lambert, Inc	425546	785357	0	Buffalo	NY	H
09/26/86	Zinc	Galvanizing	4	3312	BSC Galvanizing	424756	785035	0	Lackawanna	NY	H
09/26/86	Zinc	Zinc Plating	5	3714	Delco Products Div.	430947	774004	0	Rochester	NY	H
09/26/86	Zinc	Zinc Plating	5	3714	Delco Products Div.	430947	774004	0	Rochester	NY	H
09/26/86	Zinc	Zinc Plating	5	3714	Delco Products Div.	430947	774004	0	Rochester	NY	H
09/26/86	Zinc	Pigments/Paints	6	2818	Olin Corp.	430904	774002	0	Rochester	NY	H
09/26/86	Zinc	Surface Coating	7	3999	East Pattern/Model	430501	773531	0	Rochester	NY	H
09/26/86	Zinc	Surface Coating	8	3964	Southco-Lion Div.	425716	773427	0	Honeoye Falls	NY	H
09/26/86	Zinc	Brass/Bronze	9	3360	Columbian Bronze	403952	733510	0	Freeport	NY	H
09/26/86	Zinc	Brass/Bronze	9	3360	Columbian Bronze	403952	733510	0	Freeport	NY	H
09/26/86	Zinc	Brass/Bronze	9	3360	Columbian Bronze	403952	733510	0	Freeport	NY	H
09/26/86	Zinc	Secondary Zinc	10	3369	Gim Metal Products	404442	733708	0	Carle Place	NY	H
09/26/86	Zinc	Zinc Die Casting	11	3423	Great Neck Saw Mfgs	404439	733742	0	Mineola	NY	H
09/26/86	Zinc	Brass/Bronze	12	3362	Caldwell & Ward	430305	760852	0	Syracuse	NY	H
09/26/86	Zinc	Brass/Bronze	12	3362	Caldwell & Ward	430305	760852	0	Syracuse	NY	H
09/26/86	Zinc	Galvanizing	13	3322	Frazer and Jones Co.	430338	761345	0	Solvay	NY	H
09/26/86	Zinc	Semiconductors	14	3662	General Electric Co.	430618	761131	0	Salina	NY	H
09/26/86	Zinc	Zinc Plating	15	3452	Star Expansion Ind.	412410	740501	0	Mountainville	NY	H
09/26/86	Zinc	Secondary Zinc	16	3300	Eastern Alloys Inc.	413029	741215	0	Maybrook	NY	H
09/26/86	Zinc	Secondary Zinc	16	3300	Eastern Alloys Inc.	413029	741215	0	Maybrook	NY	H
09/26/86	Zinc	Secondary Zinc	16	3300	Eastern Alloys Inc.	413029	741215	0	Maybrook	NY	H
09/26/86	Zinc	Secondary Zinc	16	3300	Eastern Alloys Inc.	413029	741215	0	Maybrook	NY	H
09/26/86	Zinc	Secondary Zinc	16	3300	Eastern Alloys Inc.	413029	741215	0	Maybrook	NY	H
09/26/86	Zinc	Brass/Bronze	17	3494	Flomatic Corp.	425528	732036	0	N. Hoosick	NY	H
09/26/86	Zinc	Brass/Bronze	17	3494	Flomatic Corp.	425528	732036	0	N. Hoosick	NY	H
09/26/86	Zinc	Zinc Die Casting	18	3315	Amer. Tack/Hardware	410635	740358	0	Monsey	NY	H
09/26/86	Zinc	Brass/Bronze	19	3325	General Electric Co.	424824	735742	0	Schenectady	NY	H
09/26/86	Zinc	Brass/Bronze	21	3321	Goulds Pumps Inc	425448	764838	0	Seneca Falls	NY	H
09/26/86	Zinc	Zinc Die Casting	22	3644	Crown Die Casting	405329	734942	0	Mt. Vernon	NY	H
09/26/86	Zinc	Zinc Die Casting	24	3369	Die Cast & Forge Co	405337	734725	0	New Rochelle	NY	H
09/26/86	Zinc	Zinc Die Casting	25	3544	Elmsford Die Casting	410417	734826	0	Elmsford	NY	H
09/26/86	Zinc	Surface Coating	26	3471	Embee Plating	404837	735420	0	Bronx	NY	H
09/26/86	Zinc	Surface Coating	27	3953	Berry Metals Ltd.	404324	735724	0	Brooklyn	NY	H
09/26/86	Zinc	Brass/Bronze	28	3362	Thomas Paulson &Sons	404043	735926	0	Brooklyn	NY	H
09/26/86	Zinc	Brass/Bronze	28	3362	Thomas Paulson &Sons	404043	735926	0	Brooklyn	NY	H
09/26/86	Zinc	Surface Coating	29	3823	O. Z. Gedney Co.	404053	735926	0	Brooklyn	NY	H
09/26/86	Zinc	Zinc Die Casting	30	3369	Allen Stevens Corp.	404519	735358	0	Queens	NY	H
09/26/86	Zinc	Hardware	31	3429	Faultless Caster Co.	365048	872727	0	Hopkinsville	KY	H
09/26/86	Zinc	Construct. machinery	32	3531	FMC Constr. Equipmt.	380050	842557	0	Lexington	KY	H
09/26/86	Zinc	Plating, polishing	33	3471	Centr. Ky Processing	380104	842653	0	Lexington	KY	H
09/26/86	Zinc	Metal coating	34	3479	Blue Grass Plating	374415	871715	0	Richmond	KY	F
09/26/86	Zinc	Metal coating	34	3479	Blue Grass Plating	374415	871715	0	Richmond	KY	F
09/26/86	Zinc	Motor vehicle parts	35	3714	Signet Systems Inc.	374638	845110	0	Harrodsburg	KY	H
09/26/86	Zinc	Motor vehicle parts	35	3714	Signet Systems Inc.	374638	845110	0	Harrodsburg	KY	H

ZINC

PLANT NO.	STACK NO.	STACK HEIGHT, M	AREA, M2	VENT TYPE	STACK DIAMETER, M	VELOCITY, M/S	TEMP., K	EMISSIONS MAXIMUM, KG/YR	EMISSIONS, KG/YR	PROCESS DESCRIPTION	TYPE OF CONTROL
2	1	6.10	6.20	0	1.016	15.850	322	0.000	707.616	Crucible Furnace	UNC
2	2	6.10	6.20	0	1.016	15.850	322	0.000	707.616	Crucible Furnace	UNC
2	3	3.05	1.24	0	0.406	24.780	322	0.000	489.888	Polishing	UNC
3	1	15.24	2.32	0	0.152	17.343	294	0.000	90.720	Mixing	SC
4	1	40.54	54.57	0	1.346	13.259	644	0.000	83.100	Flux Drying Oven	UNC
5	1	10.36	3.42	0	0.330	8.534	297	0.000	1.814	Plating Bath	UNC
5	2	10.36	3.42	0	0.330	7.315	297	0.000	1.814	Plating Bath	UNC
5	3	10.36	3.42	0	0.330	9.144	297	0.000	1.814	Plating Bath	UNC
5	4	10.36	3.42	0	0.330	8.534	297	0.000	1.814	Plating Bath	UNC
6	1	7.32	2.97	0	0.406	0.820	294	0.000	69.673	Solids Drying	UNC
7	1	4.88	3.49	0	0.716	5.861	294	0.000	2.322	Metal Spray	UNC
8	1	9.45	7.03	0	0.744	10.820	295	0.000	93.895	Bake Oven	UNC
9	1	7.62	2.90	0	0.381	27.036	294	0.000	127.008	Melting Pot	BH
9	2	9.14	13.93	0	1.524	2.774	294	0.000	154.224	Polishing	CYC
9	3	6.71	4.95	0	0.737	38.557	294	0.000	54.432	Polishing	CYC
9	4	5.18	2.90	0	0.559	19.903	294	0.000	54.432	Polishing	CYC
10	1	8.23	2.93	0	0.356	6.401	394	0.000	81.648	Scrap Remelting	UNC
11	1	5.49	2.09	0	0.381	21.336	294	0.000	1451.520	Polishing	CYC
12	1	9.14	4.18	0	0.457	0.000	477	0.000	609.638	Crucible Furnace	UNC
12	2	9.14	4.18	0	0.457	0.000	477	0.000	609.638	Crucible Furnace	UNC
13	1	6.10	9.30	0	1.524	4.877	294	0.000	261.274	Galvanizer	UNC
14	1	15.85	6.85	0	0.432	11.156	294	0.000	52.255	Manufacture SC	UNC
15	1	7.92	11.26	0	1.422	12.192	297	0.000	5.216	Plating Tank	WS
16	1	15.54	11.84	0	0.762	10.058	339	0.000	108.864	Ball Mill	BH
16	1	15.54	11.84	0	0.762	10.058	339	0.000	399.168	Chip Melting	BH/AB
16	2	15.54	11.84	0	0.762	10.058	339	0.000	108.864	Ball Mill	BH
16	2	15.54	11.84	0	0.762	10.058	339	0.000	399.168	Chip Melting	BH/AB
16	2	15.54	11.84	0	0.762	10.058	339	0.000	199.584	Rotary Kiln	BH/AB
17	1	7.62	5.81	0	0.762	24.079	344	0.000	8110.368	Crucible Furnace	UNC
17	2	7.62	5.81	0	0.762	24.079	293	0.000	8110.368	Elec/Induct Furn	UNC
18	1	7.62	4.65	0	0.610	10.973	294	0.000	69.673	Casting	UNC
19	1	12.19	2.47	0	0.203	3.840	322	0.000	3.266	Crucible Furnace	UNC
21	1	10.06	5.88	0	0.584	11.582	305	0.000	33.612	Elec/Induct Furn	BH
22	1	7.32	10.91	0	1.491	4.907	294	0.000	11.975	Casting	UNC
24	1	6.40	2.28	0	0.356	10.363	316	0.000	0.798	Casting	UNC
25	1	5.49	5.02	0	0.914	0.457	477	0.000	1.021	Melt/Cast	UNC
26	1	10.06	15.00	0	1.491	2.896	294	0.000	48.535	Polishing	CYC
27	1	10.67	9.15	0	0.858	2.316	294	0.000	15.876	Sanding	CYC
28	1	6.71	3.46	0	0.516	25.286	477	0.000	76.658	Melting Pot	CYC
28	2	12.19	12.51	0	1.026	0.671	366	0.000	22.226	Melting Pot	UNC
29	1	6.10	2.79	0	0.457	6.325	294	0.000	9.979	Spray Booth	FILTER
30	1	5.49	6.69	0	1.219	7.681	300	0.000	162.915	Melt/Cast	UNC
31	1	8.00	4.00	0	0.500	9.000	316	0.000	50.848	Melting furnace	UNC
32	1	10.00	2.00	0	0.200	15.000	298	0.000	3.632	Brazing operation	UNC
33	1	3.00	0.90	0	0.300	1.000	311	0.000	227.000	Zinc plating tank	UNC
34	1	0.00	1000.00	0	0.000	0.000	299	0.000	76.272	Rack zinc plate	UNC
34	1	0.00	1000.00	0	0.000	0.000	299	0.000	88.076	Barrel zinc plate	UNC
35	1	9.00	1.80	0	0.200	4.000	299	0.000	8.172	Solder repair	UNC
35	2	2.00	0.40	0	0.200	4.000	299	0.000	8.172	Solder repair	UNC

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State Permit Data
HEM Input Parameters
ZINC OXIDE

UPDATE	POLLUTANT	SOURCE CATEGORY	PLANT NO.	SIC CODE	PLANT NAME	LATITUDE	LONGITUDE	URBAN	CITY	STATE	TYPE
09/26/86	Zinc oxide	Business Machines	1	3573	IBM Corp.	420621	760241	0	Endicott	NY	H
09/26/86	Zinc oxide	Surface Coating	2	3555	Luminite	421120	784452	0	Salamanca	NY	H
09/26/86	Zinc oxide	Surface Coating	3	2522	Afro-Lecon, Watson Ind	420544	791351	0	Jamestown	NY	H
09/26/86	Zinc oxide	Surface Coating	4	3484	Remington Arms Co.	430047	750159	0	Ilion	NY	H
09/26/86	Zinc oxide	Surface Coating	6	3569	Metco Inc.	404550	733308	0	Westbury	NY	H
09/26/86	Zinc oxide	Surface Coating	6	3569	Metco Inc.	404550	733308	0	Westbury	NY	H
09/26/86	Zinc oxide	Surface Coating	6	3569	Metco Inc.	404550	733308	0	Westbury	NY	H
09/26/86	Zinc oxide	Surface Coating	6	3569	Metco Inc.	404550	733308	0	Westbury	NY	H
09/26/86	Zinc oxide	Glass/Ceramics	7	3297	Tam Ceramics	430852	790218	0	Niagra Falls	NY	H
09/26/86	Zinc oxide	Glass/Ceramics	7	3297	Tam Ceramics	430852	790218	0	Niagra Falls	NY	H
09/26/86	Zinc oxide	Glass/Ceramics	7	3297	Tam Ceramics	430852	790218	0	Niagra Falls	NY	H
09/26/86	Zinc oxide	Detergents, etc.	9	2842	Proctor & Gamble	403822	741102	0	Staten Island	NY	H
09/26/86	Zinc oxide	Detergents, etc.	9	2842	Proctor & Gamble	403822	741102	0	Staten Island	NY	H
09/26/86	Zinc oxide	Detergents, etc.	9	2842	Proctor & Gamble	403822	741102	0	Staten Island	NY	H
09/26/86	Zinc oxide	Detergents, etc.	9	2842	Proctor & Gamble	403822	741102	0	Staten Island	NY	H
09/26/86	Zinc oxide	Detergents, etc.	9	2842	Proctor & Gamble	403822	741102	0	Staten Island	NY	H
09/26/86	Zinc oxide	Surface Coating	10	3823	O. Z. Gedney Co.	404053	735926	0	Brooklyn	NY	H
09/26/86	Zinc oxide	Paints/pigments	11	2851	Sherwin Williams Co.	414105	873628	0	Chicago	IL	H

ZINC OXIDE

PLANT NO.	STACK NO.	STACK HEIGHT, M	AREA, M2	VENT TYPE	STACK DIAMETER, M	VELOCITY, M/S	TEMP., K	EMISSIONS MAXIMUM, KG/YR	EMISSIONS, KG/YR	PROCESS DESCRIPTION	TYPE OF CONTROL
1	1	9.75	5.67	0	0.582	2.819	294	0.000	4.990	Fume Hood	UNC
2	1	5.49	1.67	0	0.305	19.404	311	0.000	71.215	Metal Spray	FILTER
3	1	19.81	12.08	0	0.610	15.039	294	0.000	91.627	Paint Spray	FILTER
4	1	9.14	5.58	0	0.610	12.192	297	0.000	1.361	Metal Spray	Louver collector
6	1	4.27	2.60	0	0.610	15.850	294	0.000	3.629	Wire/powder Spr.	UNC
6	1	4.27	2.60	0	0.610	15.850	294	0.000	3.629	Wire/powder Spr.	UNC
6	1	4.27	2.60	0	0.610	15.850	294	0.000	3.629	Wire/powder Spr.	UNC
6	1	4.27	2.60	0	0.610	15.850	294	0.000	10.886	Wire/powder Spr.	FILTER
7	1	7.62	8.13	0	1.067	9.114	489	0.000	288.490	Rotary Calciner	Settling chamber
7	1	7.62	8.13	0	1.067	9.114	489	0.000	152.410	Rotary Calciner	Settling chamber
7	1	7.62	8.13	0	1.067	9.114	489	0.000	440.899	Rotary Calciner	Settling chamber
9	1	20.73	12.65	0	0.610	3.719	294	0.000	9.526	Fat Blend Tank	UNC
9	1	20.73	12.65	0	0.610	3.719	294	0.000	9.526	Fat Blend Tank	UNC
9	1	20.73	12.65	0	0.610	3.719	294	0.000	9.526	Fat Blend Tank	UNC
9	1	20.73	12.65	0	0.610	3.719	294	0.000	9.526	Fat Blend Tank	UNC
9	1	20.73	12.65	0	0.610	3.719	294	0.000	37.649	Fat Blend Tank	Spray tower
10	1	6.10	2.79	0	0.457	6.325	294	0.000	8.165	Spray Booth	FILTER
11	1	24.10	14.70	0	0.610	38.100	294	0.000	16.240	Paint Mixers,dispersers	BAGHOUSES

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Summary of State of Illinois
Permit Data for Zinc/Zinc Oxide
Producers and Emitters

Source Category	Process	Pollutant	Plant Name	Stack Data: Height Ft.	Diameter Ft.	FLOWRATE ACFM	Temp F	Emissions, TSP
Iron/Steel	Lime Cleaner	Zinc	Granite City Steel	56.00	2.500	17030.000	80	16030.800
Iron/Steel	Galvanizing Pot	Zinc	Granite City Steel	80.00	0.000	0.000	0	15768.000
Iron/Steel	Galvanizing Pot	Zinc	Granite City Steel	80.00	0.000	0.000	0	19272.000
Iron/Steel	Galvanizing Line	Zinc	Granite City Steel	80.00	2.500	17672.000	80	4380.000
Iron/Steel	2 vessels	Zinc	Granite City Steel	160.00	18.000	800000.000	550	324996.000
Iron/Steel	Charge and Tap	Zinc	Granite City Steel	150.00	0.000	0.000	0	19344.000
Iron/Steel	Metal Reladling	Zinc	Granite City Steel	60.00	9.300	300000.000	425	4993.200
Iron/Steel	Metal Charging	Zinc	Granite City Steel	67.00	2.800	30000.000	140	350.400
Iron/Steel	CalCarb. Desulf	Zinc	Granite City Steel	60.00	4.600	300000.000	350	4204.800
Iron/Steel	Injection	Zinc	Granite City Steel	60.00	4.600	300000.000	350	438.000
Galvanizing	Zinc Bath	Zinc	Keystone Steel/Wire	60.00	0.000	0.000	0	588.000
Galvanizing	Muffle Annealing	Zinc	Keystone Steel/Wire	50.00	0.000	0.000	0	1176.000
Galvanizing	Nail Galvanizing	Zinc	Keystone Steel/Wire	10.00	0.000	0.000	0	37632.000
Galvanizing	Ingot Teeming	Zinc	Keystone Steel/Wire	100.00	0.000	0.000	0	48020.000
Galvanizing	Cont. Caster	Zinc	Keystone Steel/Wire	80.00	0.000	0.000	0	8232.000
Galvanizing	Arc Furnace	Zinc	Keystone Steel/Wire	70.00	17.000	200000.000	250	219300.000
Galvanizing	Nail Galvanizing	Zinc	Keystone Steel/Wire	40.00	2.500	10000.000	400	9240.000
Galvanizing	Nail Galvanizing	Zinc	Keystone Steel/Wire	40.00	2.500	10000.000	400	9240.000
Secondary Zinc	Elec/Induct Furn	Zinc	R. Lavin and Son	42.00	6.000	23071.000	500	798.000
Secondary Zinc	Elec/Induct Furn	Zinc	R. Lavin and Son	70.00	3.000	17580.000	100	789.600
Brass/Bronze	Reverb. Furnaces	Zinc	N. Chicago Refiners	28.00	6.400	20000.000	145	51861.600
Brass/Bronze	Brass Cupola	Zinc	N. Chicago Refiners	48.00	11.500	43500.000	230	116640.000
Brass/Bronze	Crucible Furnace	Zinc	N. Chicago Refiners	43.00	1.800	1858.000	830	41.600
Brass/Bronze	Rotary Furnaces	Zinc	N. Chicago Refiners	50.00	0.000	0.000	0	53913.600
Secondary Zinc	Fr. Muffle Furn.	Zinc Oxide	Asarco, Inc.	25.00	0.000	37680.000	158	23652.000
Secondary Zinc	Fr. Muffle Furn.	Zinc Oxide	Asarco, Inc.	10.00	4.900	45530.000	158	23652.000
Secondary Zinc	Fr. Z.O. Packer	Zinc Oxide	Asarco, Inc.	15.00	0.500	1220.000	70	350.400
Secondary Zinc	Storage/Handling	Zinc Oxide	Asarco, Inc.	25.00	1.100	1200.000	70	525.600
Secondary Zinc	Bolting Mill	Zinc Oxide	Asarco, Inc.	5.00	1.100	1200.000	70	525.600
Secondary Zinc	W.S. Crusher	Zinc Oxide	Asarco, Inc.	8.00	0.000	0.000	0	240.000

HEM INPUT PARAMETERS FOR ZINC/ZINC OXIDE PRELIMINARY SOURCE ASSESSMENT
SPECIALITY STEEL PLANTS

PLANT NAME	STATE	LAT.	LONG.	POLLUTANT	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	AREA (SQM)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Allegheny Ludlum	PA	403500	794300	ZnO	30.48	929	-	65.03	0.61	333	10.9	EAF-DEC	BH
				Zn	30.48	929		65.03	0.61	333	4.3		
				ZnO	30.48	929		65.03	0.61	333	10.9	EAF-DEC	BH
				Zn	30.48	929		65.03	0.61	333	4.3		
				ZnO	30.48	557		39	0.7	333	10.9	EAF-DEC	BH
				Zn	30.48	557		39	0.7	333	4.3		
				ZnO	30.48	465		32.5	0.4	333	10.9	EAF-DEC	BH
				Zn	30.48	465		32.5	0.4	333	4.3		
				ZnO	30.48	1486		148.64	2.37	333	2480	2 EAF's;	BH
				Zn	30.48	1486		148.64	2.37	333	984	AOD	
				ZnO	30.48	1115		148.64	2.17	333	2.2	2 EAF's	BH
				Zn	30.48	1115		148.64	2.17	333	0.86		
				ZnO	15.2	2787		5574	0.5	305	13300	Fug.- EAF,	Closed
				Zn	15.2	2787		5574	0.5	305	5300	AOD	Roof
Al Tech	NY	424238	734326	ZnO	16.76	536.5		117	2.41	316	1690	2 EAF's;	
				Zn	16.76	536.5		117	2.41	316	671	2 AOD	BH
				ZnO	19.8	2657		4460	0.5	305	6620	Fug.- EAF,	Closed
				Zn	19.8	2657		4460	3.53	305	2630	AOD	Roof
Armco	MD	391815	763408	ZnO	24.68	451.5		39.01	3.53	311	570	AOD; EAF	BH
				Zn	24.68	451.5		39.01	3.53	311	226		
				ZnO	17.06	2123		57.96	0.5	305	13900	Fug. EAF,	Roof
				Zn	17.06	2123		57.96	0.5	305	5500	AOD	Monitor
Armco	PA	405100	795300	ZnO	46	84.2	1.8	-	20.8	333	70	EAF, DEC	Venturi
				Zn	46	84.2	1.8		20.8	333	28		Scrubber
				ZnO	46	84.2	1.8		20.8	333	70	EAF, DEC	Venturi
				Zn	46	84.2	1.8		20.8	333	28		Scrubber
				ZnO	46	84.2	1.8		20.8	333	70	EAF, DEC	Venturi
				Zn	46	84.2	1.8		20.8	333	28		Scrubber
				ZnO	23.7	550		395.2	0.88	319	1080	3 EAF, AOD	2 BH's
				Zn	23.7	550		395.2	0.88	319	429		
				ZnO	44	5898		332	0.5	305	38400	Fug.- EAF,	Roof
				Zn	44	5898		332	0.5	305	15300	AOD	Monitor

HEM INPUT PARAMETERS FOR ZINC/ZINC OXIDE PRELIMINARY SOURCE ASSESSMENT
SPECIALITY STEEL PLANTS (continued)

PLANT NAME	STATE	LAT.	LONG.	POLLUTANT	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	AREA (SQM)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Cabot	IN	402830	860944	ZnO	6.24	47.6	-	0.93	7.9	394	40	2 AOD	BH
				Zn	6.24	47.6		0.93	7.9	394	16		
				ZnO	12.95	237		6.96	4.67	355	0.87	2 EAF	BH
				Zn	12.95	237		6.96	4.67	355	0.35		
				ZnO	19.8	2415		1742	0.5	305	510	Fug.- AOD,	Roof
				Zn	19.8	2415		1742	0.5	305	210	EAF	fans
Carpenter Tech-nology	CN	411000	731000	ZnO	28	932		142	2.2	311	740	2 EAF,	BH
				Zn	28	932		142	2.2	311	294	AOD	
				ZnO	30.5	5574		2787	0.5	305	3260	Fug.- EAF,	Closed
				Zn	30.5	5574		2787	0.5	305	1300	AOD	Roof
Carpenter Tech-nology	PA	402147	755555	ZnO	24.4	795		54.67	3.35	303	37	EAF, AOD	BH
				Zn	24.4	795		54.67	3.35	303	15		
				ZnO	23.7	775		119.3	2.67	303	207	3 EAF's,	BH
				Zn	23.7	775		119.3	2.67	303	82	AOD	
				ZnO	24.4	4460		5574	0.5	305	2230	Fug.- EAF's,	Closed
				Zn	24.4	4460		5574	0.5	305	884	AOD	Roof
Crucible	NY	400300	761000	ZnO	15.2	232		8.36	6.2	408	72	2 EAF's,	BH
				Zn	15.2	232		8.36	6.2	408	29	DEC	
				ZnO	38.8	649		40.87	3.87	311	420	1 AOD	BH
				Zn	38.8	649		40.87	3.87	311	167		
				ZnO	22.86	2787		92.9	0.5	305	1970	Fug.- EAF's,	Roof
				Zn	22.86	2787		92.9	0.5	305	783	AOD	Monitor
Eastern Stain-less	MD	391744	763051	ZnO	25.9	632		29.7	3.65	316	1650	AOD	BH
				Zn	25.9	632		29.7	3.65	316	655		
				ZnO	22.86	15.8	2.28		26.5	311	21	EAF	BH
				Zn	22.86	15.8	2.28		26.5	311	8.4		
				ZnO	22.86	2090		1394	0.5	305	18800	Fug.- EAF,	Closed
				Zn	22.86	2090		1394	0.5	305	7460	AOD	Roof
Empire Detroit Steel	OH	404700	823100	ZnO	28	735		138.5	1.71	339	71	2 EAF's,	BH
				Zn	28	735		138.5	1.71	339	28	AOD - DEC	
				ZnO	28	3419		9232	0.5	305	7830	Fug.- EAF,	Roof
				Zn	28	3419		9232	0.5	305	3110	AOD	Monitor

HEM INPUT PARAMETERS FOR ZINC/ZINC OXIDE PRELIMINARY SOURCE ASSESSMENT
SPECIALITY STEEL PLANTS (continued)

PLANT NAME	STATE	LAT.	LONG.	POLLUTANT	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	AREA (SQM)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Jessop Steel	PA	401038	801602	ZnO	12.8	215	-	12.5	9.81	316	7.3	3 EAF's	BH
				Zn	12.8	215		12.5	9.81	316	2.9		
				ZnO	11.3	120		6.27	4.2	339	420	AOD	BH
				Zn	11.3	120		6.27	4.2	339	166		
				ZnO	19.8	2657		5946	0.5	305	2280	Fug.- EAF, AOD	Closed Roof
				Zn	19.8	2657		5946	0.5	305	907		
Earle M. Jorgensen	WA	471200	1220200	ZnO	15.2	290		6.5	38.1	294	163	2 EAF's, AOD	BH
				Zn	15.2	290		6.5	38.1	294	65		
				ZnO	19.8	2415		2323	0.5	305	178	Fug.- EAF, AOD	Closed Roof
				Zn	19.8	2415		2323	0.5	305	71.3		
Slater Steel	IN	410412	851017	ZnO	8.8	13.37	1.52		13	394	608	AOD	BH
				Zn	8.8	13.37	1.52		13	394	242		
				ZnO	8.2	16.23	1.98		15.4	308	19.6	EAF, AOD	BH
				Zn	8.2	16.23	1.98		15.4	308	7.8		
				ZnO	12.2	40.87	3.35		10.7	322	10.7	EAF	BH
				Zn	12.2	40.87	3.35		10.7	322	4.3		
				ZnO	25.9	4738		1394	0.5	305	1410	Fug.- EAF, AOD	Closed Roof
				Zn	25.9	4738		1394	0.5	305	559		
Wash-ington Steel	PA	401500	801200	ZnO	19.2	632		110.4	1.32	316	1010	2 EAF's, AOD	BH
				Zn	19.2	632		110.4	1.32	316	400		
				ZnO	19.8	2415		2323	0.5	305	10700	Fug.- 2 EAF's, AOD	Closed Roof
				Zn	19.8	2415		2323	0.5	305	4230		
Cytemp Spe-ciality Steel	PA	402100	800700	ZnO	21.3	650		56.7	5.07	322	549	3 EAF's, AOD	BH
				Zn	21.3	650		56.7	5.07	322	218		
				ZnO	27.4	3344		4460	0.5	305	1150	Fug.- EAF, AOD	Closed Roof
				Zn	27.4	3344		4460	0.5	305	458		
LTV Steel	OH	404812	812010	ZnO	33.5	3065		446	2.09	314	6.38	4 EAF's - DEC Systems	BH
				Zn	33.5	3065		446	2.09	314	2.53		
				ZnO	29.6	2451		202	2.7	303	1140	3 EAF's, AOD	BH
				Zn	29.6	2451		202	2.7	303	452		
				ZnO	26.2	3515		637	0.5	305	44	Fug.- EAF	Roof Monitor
				Zn	26.2	3515		637	0.5	305	17.3		
				ZnO	43.3	5804		163.5	0.5	305	28400	Fug.- EAF, AOD	Roof Monitor
				Zn	43.3	5804		163.5	0.5	305	11300		

HEM INPUT PARAMETERS FOR ZINC/ZINC OXIDE PRELIMINARY SOURCE ASSESSMENT
SPECIALITY STEEL PLANTS (continued)

PLANT NAME	STATE	LAT.	LONG.	POLLUTANT	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	AREA (SQM)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Electralloy	PA	794700	412550	ZnO	24.4	42.2	1.1		18.1	325	964	EAF, AOD	Scrubber
				Zn	24.4	42.2	1.1		18.1	325	383		
				ZnO	12.2	2000		10	10	311	52	EAF, AOD	BH
				Zn	12.2	2000		10	10	311	21		
				ZnO	24.9	4517		1360	2	311	1090	EAF, AOD	Closed Roof
				Zn	24.9	4517		1360	2	311	435		
Standard Steel	PA	773356	403924	ZnO	26.5	675		72.8	2.3	395	254	EAF, AOD	BH
				Zn	26.5	675		72.8	2.3	395	101		
				ZnO	25	2390		750	0.5	305	2180	EAF, AOD	Roof Monitor
				Zn	25	2390		750	0.5	305	864		

HEM Input Parameters for Zinc/Zinc Oxide Preliminary Source Assessment

	Pollutant	Annual Emissions (Kg/yr)	Vent Height (m)	Vent Diameter (m)	Discharge Velocity (m/sec)	Discharge Temp. (°K)
1. BOF Furnace						
A. Plant 7 - Primary Stack	ZnO	3080	114.3	2.4	18.3	350
- Secondary Stack	ZnO	19000	114.3	4.9	18.3	338
B. Plant 8 - Primary Stack	ZnO	14080	144.8	6.0	18.3	477
- Secondary Stack	ZnO	15200	144.8	4.4	18.3	338
2. Electric Arc Furnace						
A. Furnace A - Carbon Steel (25 T/Heat)	ZnO	576	22.9	15.2 x 3.1	0.98	394
	Zn	288	22.9	15.2 x 3.1	0.98	394
- Roof Monitor	ZnO	979	27.4	45.7 x 3.1	3.38	320
	Zn	490	27.4	45.7 x 3.1	3.38	320
B. Furnace B - Carbon Steel (100 T/Heat)	ZnO	2490	22.9	15.2 x 3.1	3.91	394
	Zn	1250	22.9	15.2 x 3.1	3.91	394
- Roof Monitor	ZnO	4270	33.5	68.6 x 3.1	3.74	320
	Zn	2140	33.5	68.6 x 3.1	3.74	320
C. Furnace C - Carbon Steel (300 T/Heat)	ZnO	3690	30.5	22.9 x 3.1	3.15	394
	Zn	1850	30.5	22.9 x 3.1	3.15	394
- Roof Monitor	ZnO	15600	38.1	107 x 3.1	4.00	320
	Zn	7800	38.1	107 x 3.1	4.00	320
D. Furnace D - Carbon Steel (150 T/Heat)	ZnO	4600	30.5	22.9 x 3.1	4.06	394
	Zn	2300	30.5	22.9 x 3.1	4.06	394
- Roof Monitor	ZnO	11500	36.6	76.2 x 3.1	3.90	320
	Zn	5750	36.6	76.2 x 3.1	3.90	320